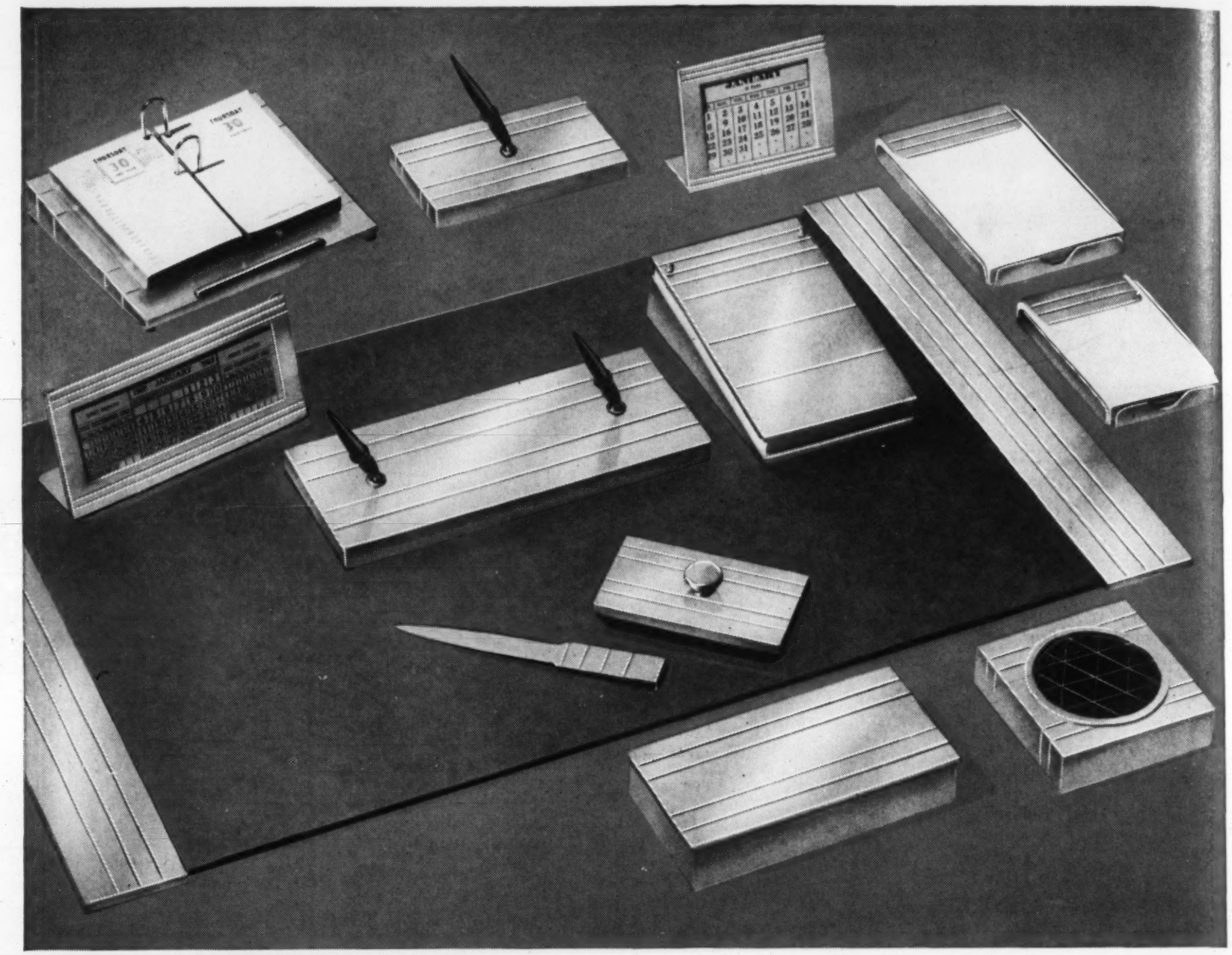
Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES



A few of the fine executive desk appointments made of Formbrite by Smith Metal Arts Co., Inc.

For a superfine luster that lasts—superfine-grain Formbrite

Smith Metal Arts Co. uses easy-to-polish, scratch-resistant Formbrite to add value to its line of distinguished desk appointments.

The fine executive desk appointments made by Smith Metal Arts Co., Inc., Buffalo, N. Y., are not just polished to shine. They are brought up to a beautiful deep luster. For their line of brass accessories they use Formbrite,® Anaconda's superfine-grain drawing brass.

They have found that the fine, uniform grain size of Formbrite enables them to give their pieces a superior, more uniform texture. The luster, furthermore, stands up better under handling because Formbrite provides a harder, more scratch-resistant surface.

In order to achieve this fine luster, Smith Metal Arts Co. must do an exceptional amount of polishing and they have chosen Formbrite because of its superior polishing characteristics. By using Formbrite they can achieve their high quality surfaces at savings of 20% over the use of ordinary brass.

See for yourself. Formbrite is a premium product at a nonpremium price. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you improve product quality, lower finishing costs. Write for Publication B-39. Better yet, ask for a sample or details on our trial order offer. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5771

Formbrite

SUPERFINE-GRAIN DRAWING BRASS

an ANACONDA® product

Made by The American Brass Company

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Materials in Design Engineering®

formerly Materials & Methods

Selection & use of metals, nonmetallics, forms, finishes

AUGUST 1957 **VOL. 46, NO. 2**

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This periodical is indexed regularly in the Engineering Index and the Industrial Arts Index

Paint removing tool made with nickel alloy:

Easy way out of a tough scrape

This pretty miss has waded into a job that strong men often shun.

But don't worry. With that electric paint remover, she won't raise a single blister — except on paint.

She needs no clumsy scraper. No messy chemicals or flaming blowtorch. Within minutes after she plugs into a 110-volt line, old paint is done for. She blisters it . . . softens it . . . and lifts it off with her putty knife. *No difficulties here.*

Nor, for that matter, were there difficulties on the development end. The designers of this tool simply adapted an idea that has long been used on electric ranges and other heating appliances. *They put the heating element inside a tube of Incoloy* iron-nickel-chromium alloy.*

Incoloy protects the thin nickel-chromium resistance wire against the destructive knocks and slams of use. A standout performer at high temperatures, Incoloy resists warping . . . cracking . . . corrosion . . . "burning up." It's just what the manufacturers knew they needed to assure a long-lived product for do-it-yourselfers and professionals.

Do you have a metal problem? Then look into the Inco Nickel Alloys. Their properties and applications are described in a useful booklet, *Standard Alloys for Special Problems.* Write for a copy. After reading it, you may want some specific help. We're ready to give that, too . . .

All ***INCO PLUS SERVICES*** are yours for the asking: Corrosion Engineering • High Temperature Engineering • Fabrication Help • Casting Information • Field Information Centers • Convenient Sales and Service • Technical Publications. You are welcome to all the information and help we can give you whenever you are looking for answers to your metal problems.

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Nickel Alloys Perform Better, Longer

For more information, turn to Reader Service card, circle No. 368

What's new IN MATERIALS

...AT A GLANCE

TWO NEW TITANIUM ALLOYS are available. One is a formable sheet alloy containing 16 vanadium and 2.5% aluminum. According to the producer, the alloy can be age hardened to high strength levels, yet retain usable ductility. The other alloy, containing 8 aluminum and 2% columbium, is a high temperature, weldable sheet and bar alloy. (More details next month.)

ANOTHER TITANIUM ALLOY, a titanium-aluminum-molybdenum composition shows promise for such aircraft parts as jet engine disks and blades and high strength airframe forgings and fasteners. Samples exposed to high stress at 1000 F show good strength and ductility in subsequent room temperature tensile tests. Tensile strengths exceeding 160,000 psi have been obtained in the laboratory.

MORE HEAT RESISTANT PVC FORMULATIONS are possible with a new acrylic resin modifier. According to the producer, the modifier raises the heat distortion temperature of PVC and increases its stability to light. The acrylic modifier, soluble in ketones and esters but insoluble in water, is also said to improve the processing characteristics of PVC.

A NEW ALUMINUM ALLOY is said to have weld strengths comparable to the strength of the base metal. The alloy, containing 4 magnesium, 0.45 manganese and 0.10% chromium, has a tensile strength of 38,000 to 47,000 psi. The aluminum alloy, available in plate, sheet and extrusions, is not affected by welding heat.

GRAPHITE WHISKERS, said to be ten times more conductive and ten times stronger than bulk graphite have been produced under high pressure in a carbon arc. Tensile strengths of the whiskers are as high as 88,000 psi, and higher readings are expected as test procedures improve.

MEASURING THE SIZE OF PORES IN POROUS MATERIALS is possible with a portable instrument that uses mercury. Made in England, the instrument consists of a pressure vessel to which mercury is admitted at high pressures. As pressure is increased mercury is forced into the pores, and their size is indicated by drop in mercury level in a calibrated container.

ACRYLIC RESIN-COATED NYLON FABRIC, developed in Italy and now produced in this country, is said to have excellent tear

resistance. It also has high dimensional stability and can be folded up to 70,000 times without cracking. Potential uses include upholstery materials, photographic and map papers and handbags.

A NEW FERRITE MAGNETIC CORE is expected to find wide use in the computer industry. The core is said to offer the greatest stability yet achieved for a transistor-operated core over a wide range of temperatures, currents, and other variables. Prices of the cores are said to be generally lower than for previously available cores.

BUTYL RUBBER has excellent swell resistance to such oxygen-containing hydrocarbons as alcohols, esters, ethers and ketones, recent research shows. In aromatic, aliphatic and halogenated hydrocarbons, butyl rubber generally has a high swell but retains considerable toughness even after 30 days at room temperature. These findings suggest its use where toughness, not amount of swell, is the key factor.

HOT WORKING OF CERTAIN STAINLESS STEELS can be greatly improved by adding traces of boron. Studies of boron-containing austenitic chromium-nickel and chromium-manganese alloys show the effect on hot ductility is most marked at temperatures of 2000 to 2400 F. Small boron additions do not alter grain size, but too much boron may cause a grain boundary precipitate in the annealed material.

A GRAPHITE-FILLED EPOXY RESIN has been developed to resist the corrosive action of hydrofluoric acid and other fluorides. The material is also said to resist fluorine salts and the products of reaction of hydrofluoric acid with organic and inorganic chemicals. The material is recommended for use in acid pump parts and chemical tanks.

FAIRLY DUCTILE WELDS IN MOLYBDENUM are possible with high purity, dry box atmospheres, recent research shows. However, because it is necessary to weld many pieces in air, effective air shielding methods are desirable. Of three methods studied, an inert-gas-shielding cup and a leading-trailing shield unit were best.

HARD, DUCTILE, LOW STRESS NICKEL ELECTROPLATES are possible with a new plating bath chemical. According to the producer, compressive stress in nickel deposits can be closely controlled from 0 to 8000 psi. The special chemical is intended primarily for use in the plating of printed circuts.

Turn to page 143 for more "What's New in Materials"

MATERIALS BRIEFS

Concrete Manhole Covers

Lightweight manhole covers of prestressed concrete can carry a load of 25 to 50 tons and can withstand repeated blows of a sledge hammer without breaking. The covers are made by shrinking a red hot steel ring around a mass of concrete so that the steel ring presses the concrete together to a predetermined size.

A Touch of Plastics

Braille plastics book pages are now being formed out of acetate sheets. Unlike conventional Braille, which is printed on zinc plates and requires high production, plastics Braille pages can be produced economically in small quantities.

Fishfull Thinking

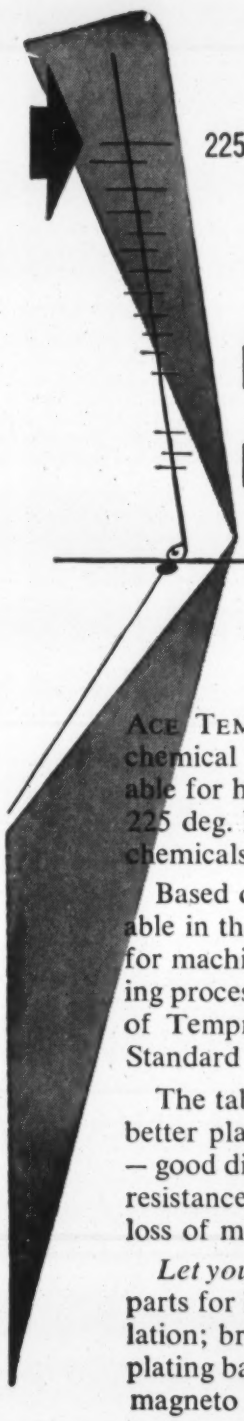
Acrylic and other synthetic fibers, bonded together with nontoxic binders, are used to remove particles of dirt and bacteria from home aquariums. The filtration medium is said to be harmless to fish, nonallergic and easy to handle.

Now It Talks

An electronic brain computes the best course and altitude for an airplane, transforms this information into a verbal message and transmits the message to the aircraft using a standard voice channel transmitter.

Clean As a Whistle

Germ-free polyethylene toys are now being offered. A chemical used in the toys not only destroys bacteria on contact but also produces "halos" or sterile areas surrounding the toy.



Now!

HARD RUBBER PARTS FOR HIGH TEMPERATURES

...ace tempron®

ACE TEMPRON, a new synthetic hard rubber, now makes the chemical resistance, strength, and economy of hard rubber available for high-temperature applications! It is stable and rigid up to 225 deg. F. and higher, and shows remarkable resistance to many chemicals when tested at 200 deg. F.

Based on nitrile synthetic rubber (Buna-N), Tempron is available in three forms: (1) Molded parts, (2) sheet, rod and tubes, for machining a wide variety of shapes; and, (3) a hand-fabricating process for making tanks, large fittings, etc., by forming sheets of Tempron around cores or mandrels prior to vulcanization. Standard pipe and fittings are also made.

The table below tells the story – high tensile on a par with the better plastics – a chance to save weight – good impact strength – good dielectric properties – excellent chemical, oil and moisture resistance – and ability to withstand high temperatures without loss of mechanical strength.

Let your imagination loose on these typical applications: molded parts for hot jobs; special fittings for corrosives; transformer insulation; brine and gasoline meter parts; trays for vacuum dryers; plating barrels; hot brine systems; tubing for electrical condensers, magneto parts.

Do you make anything that might be improved by Ace Tempron? Why not look into it? Let us know and we'll be glad to help. No obligation, of course.

PHYSICAL AND ELECTRICAL PROPERTIES OF TEMPRON

PROPERTIES	MOLDED PARTS, SHEET, ROD & TUBES	HAND-BUILT PRODUCTS
Tensile Str., psi.	7170	7500
Elongation, %	2.70	2.80
Specific Gravity	1.24	1.25
Hardness—Durometer D	87	87
Impact, ft.—lbs./in.	0.41	0.49
Flexural Str., psi.	11,300	11,800
Dielectric Str., v/mil, 60 cyc.	400	460
Power Factor, 1 kc.	0.016	0.016
Dielectric Constant, 1 kc.	3.50	3.70
Water Absorption, (48 hrs. R.T.%)	0.12	—
Heat Distortion Temp., deg. F.	275	260

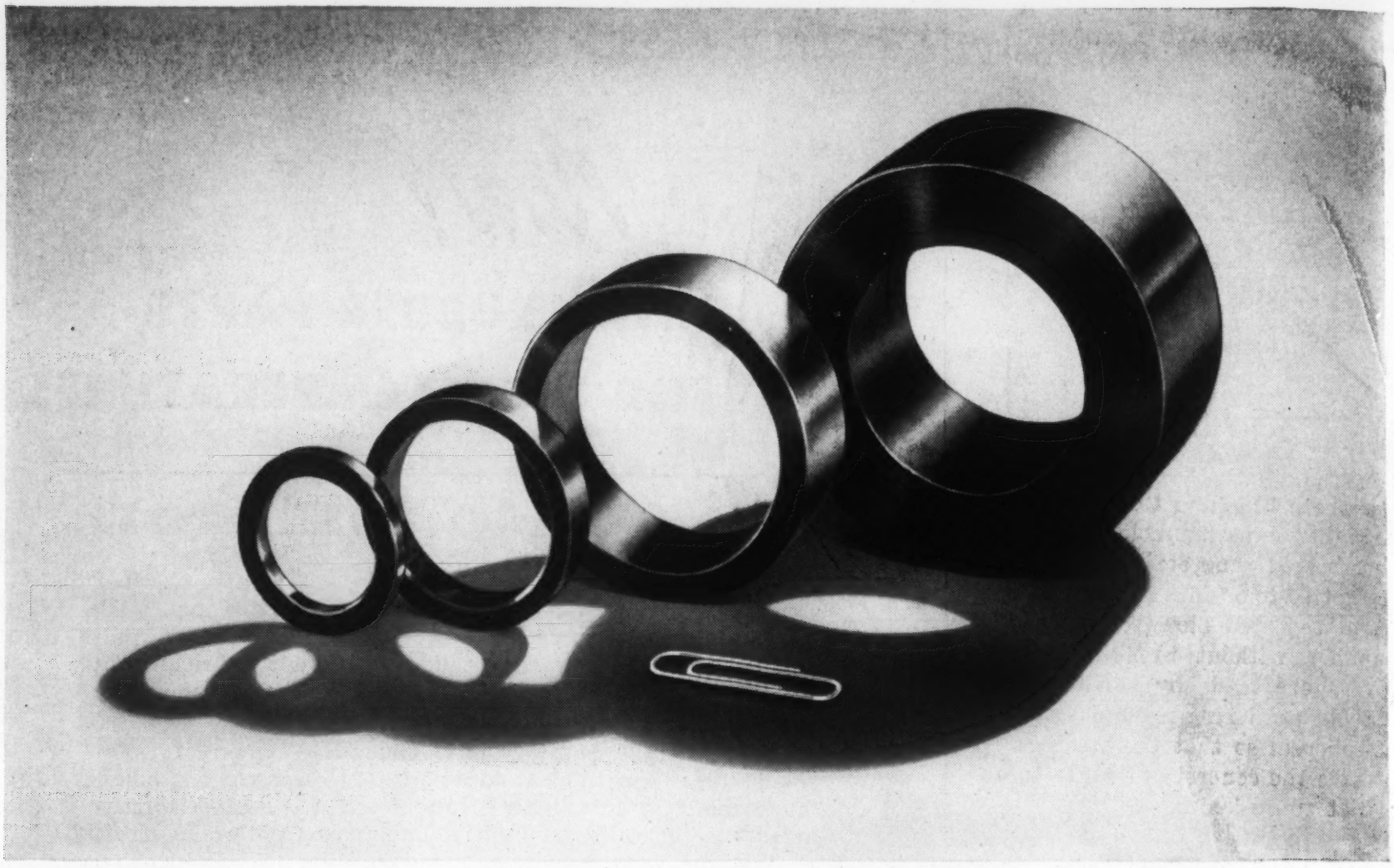
ACE® rubber and plastic products

AMERICAN HARD RUBBER COMPANY

Ace Avenue • Butler, New Jersey

DIVISION OF AMERACE CORPORATION

For more information, turn to Reader Service card, circle No. 523



More Weight in Less Space with Mallory 1000 Metal

WHATEVER the nature of your assembly—gyroscope rotors, counterbalances, balancing weights, or similar mass components—you can get more weight into less space with Mallory 1000 Metal.

Mallory 1000 has a density of 16.96 gm/cc—twice that of brass or steel, and is far stronger than lead! It features ready machineability—even to a high surface finish.

More weight in less space means real savings in several ways. For example, housings can be made smaller—thus overall assemblies become smaller for a savings in cost and weight. Mallory 1000 Metal provides exceptionally high inertia in a smaller space, increasing the sensitivity of gyroscopic or balancing action, yet reducing the overall unit size.

Complete information on Mallory 1000 Metal specifications and applications may be had on request. Write today.

Expect more . . . get more from

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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

For more information, turn to Reader Service card, circle No. 374

Nylon: new arteries for old

Noncollapsible tubes made of nylon are being used in surgery to replace damaged or diseased arteries (see photo). Called the "Y" graft (because of its shape), the nylon artery is the result of research by Alabama Medical College and Chemstrand Corp. Nylon was selected because of its combination of toughness and resilience and because it can be sterilized.

Monsanto Chemical Co.

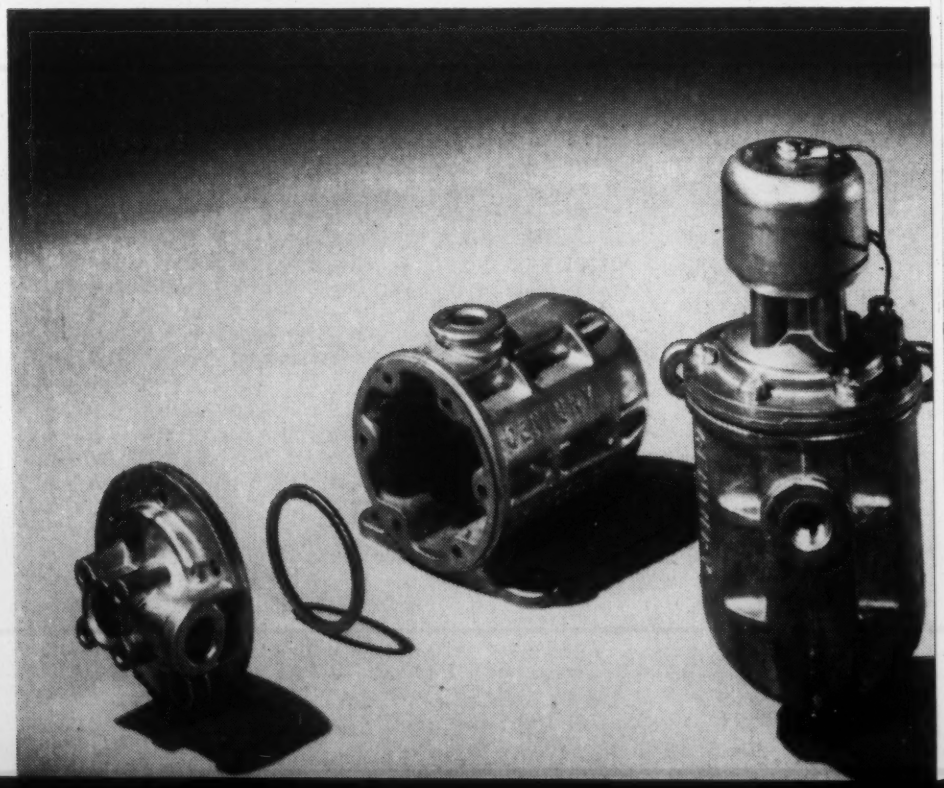
MATERIALS AT WORK

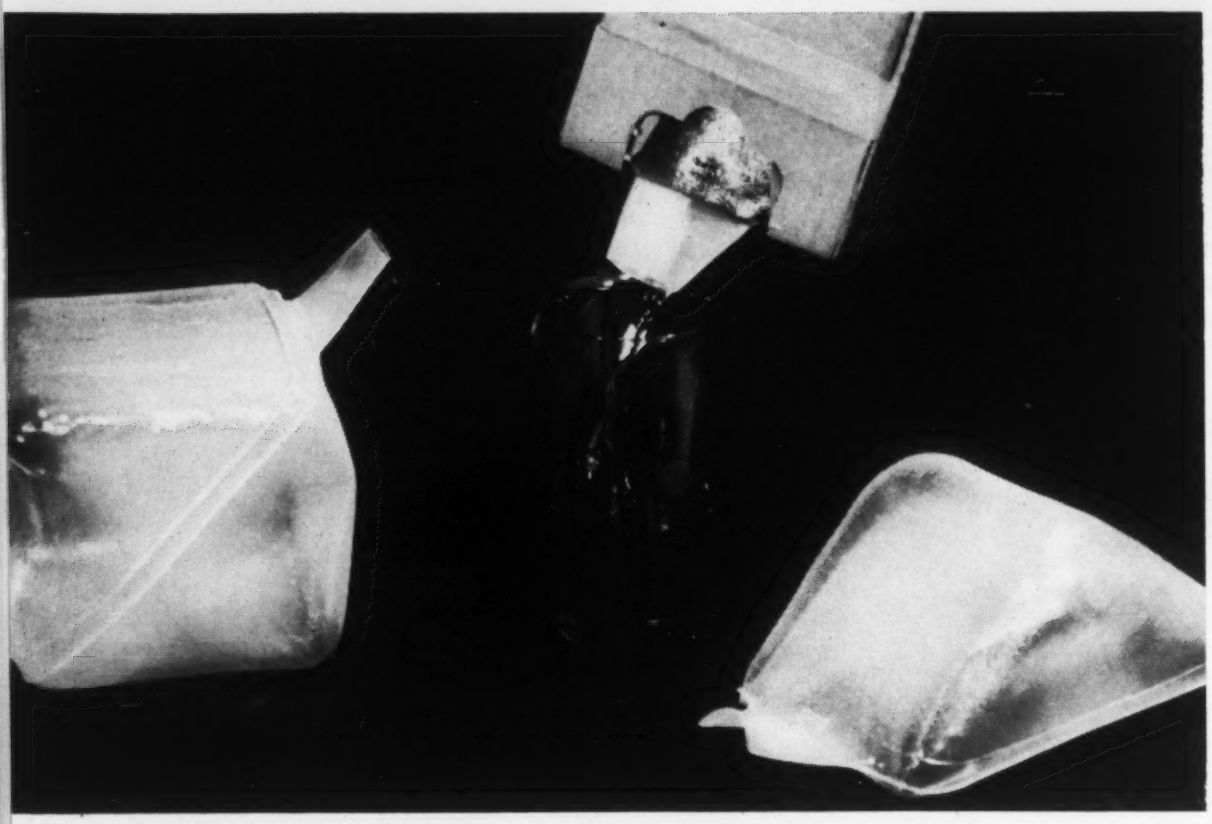
New and interesting applications of engineering materials

Aluminum die castings replace sand castings

The switch from sand castings to die castings has resulted in elimination of ten drilling, one milling and two lathe operations in the fabrication of an aluminum filter assembly. The new unit is also more compact than the old.

The filter assembly, manufactured by Century Gas Equipment Co., is composed of the three die castings shown in the photo: a body, a strainer cover and a filter pack retainer ring. The as-cast dimensional tolerances inherent in die casting provide a perfect fit of the mating filter castings, and these tolerances are held over long production runs. No surface finishing is required.





Polyethylene: Self-contained container

A new container designed for shipping, storing and dispensing liquids is being molded of Du Pont polyethylene. As shown in the photo, the convenient molded-on spout and cut-out handle make handling and pouring safe and easy.

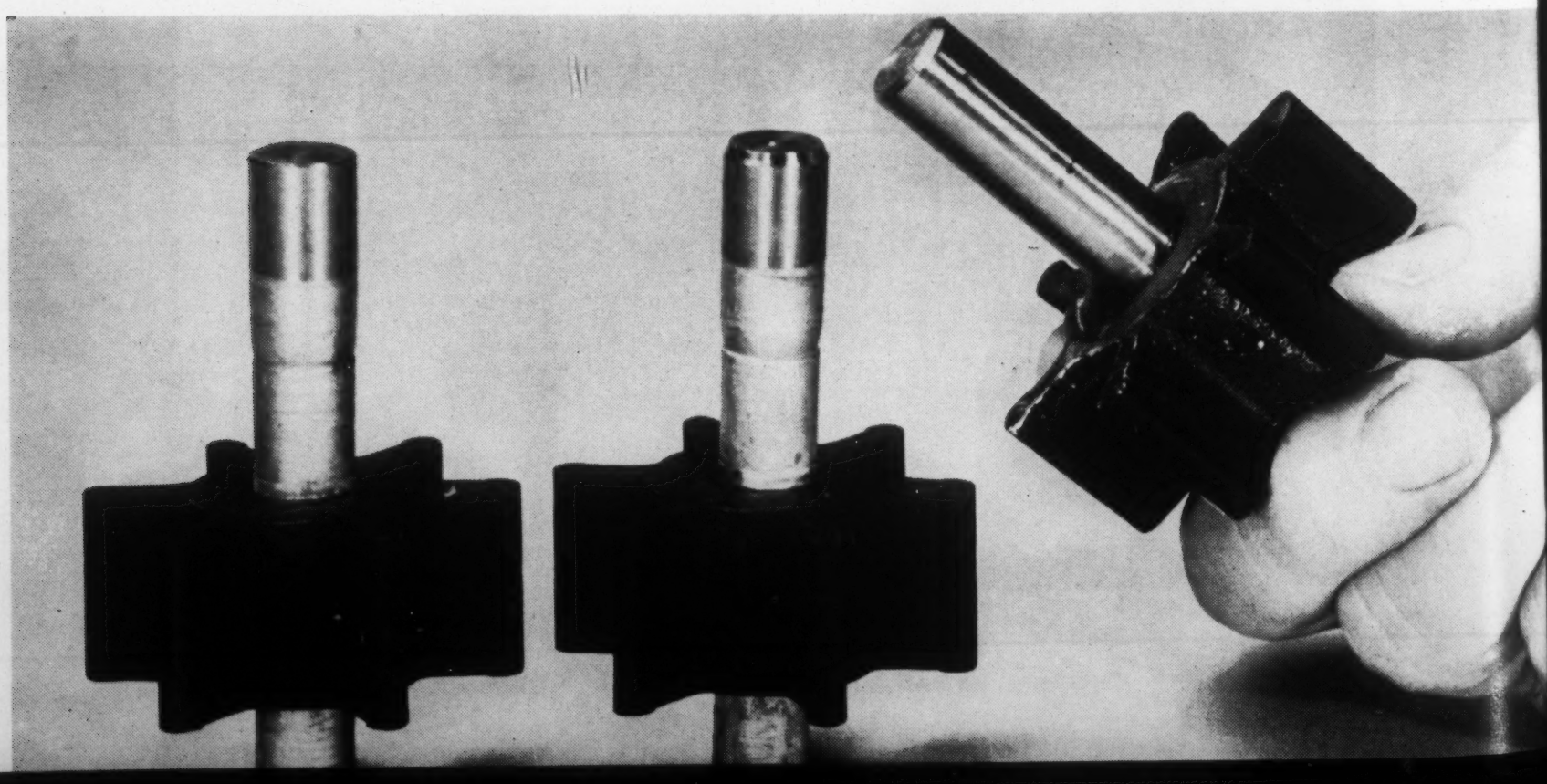
The unique package, manufactured by Hedwin Corp., is shipped to packagers collapsed and nested. The polyethylene inserts are then inflated, filled and heat sealed. When ready for use, the spout is easily snipped open. Polyethylene was chosen for this application because of its light weight, flexibility and chemical resistance.

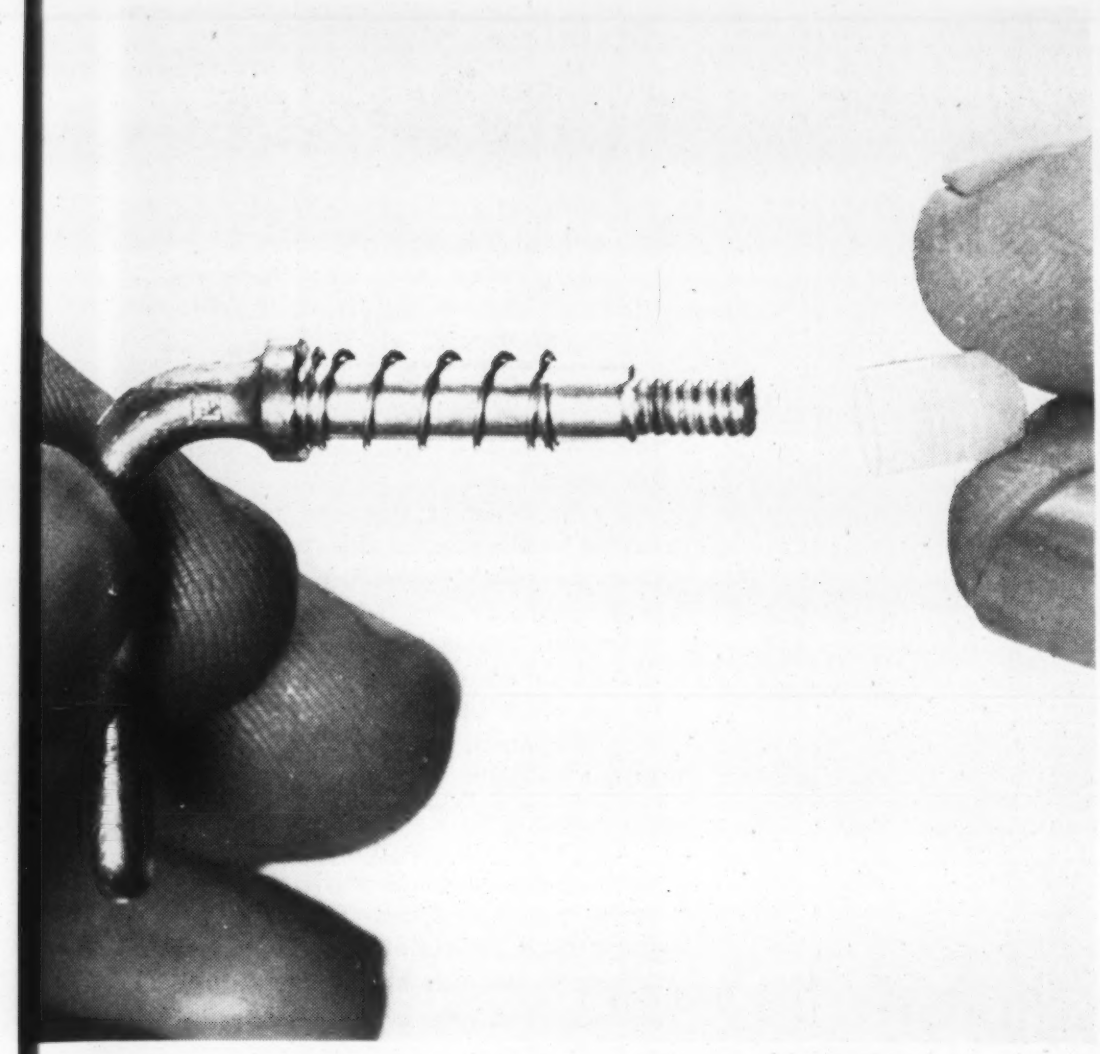
Pump for ferric chloride solution made possible by titanium shaft

Because of its resistance to chlorides, commercially pure titanium has enabled Jabsco Pump Co. to develop a pump to replace batch handling of ferric chloride used to etch printed circuits.

According to Mallory-Sharon Titanium Corp., suppliers of the titanium, the corrosive nature of the ferric chloride acid solution and the tight seal needed to prevent leakage made it difficult to select a metal shaft for this pump which would have a reasonable life. Steel shafts plated with nickel, silver and rhodium were tried, but these lasted only 45 min. before the pump started to leak; and glass shafts proved too weak.

The titanium shaft (being held in photo) was found to be ideal. After 321 hr of operation, the pump was examined for damage that might lead to leakage, and none was found.





Zinc + nylon + steel = better springbolt

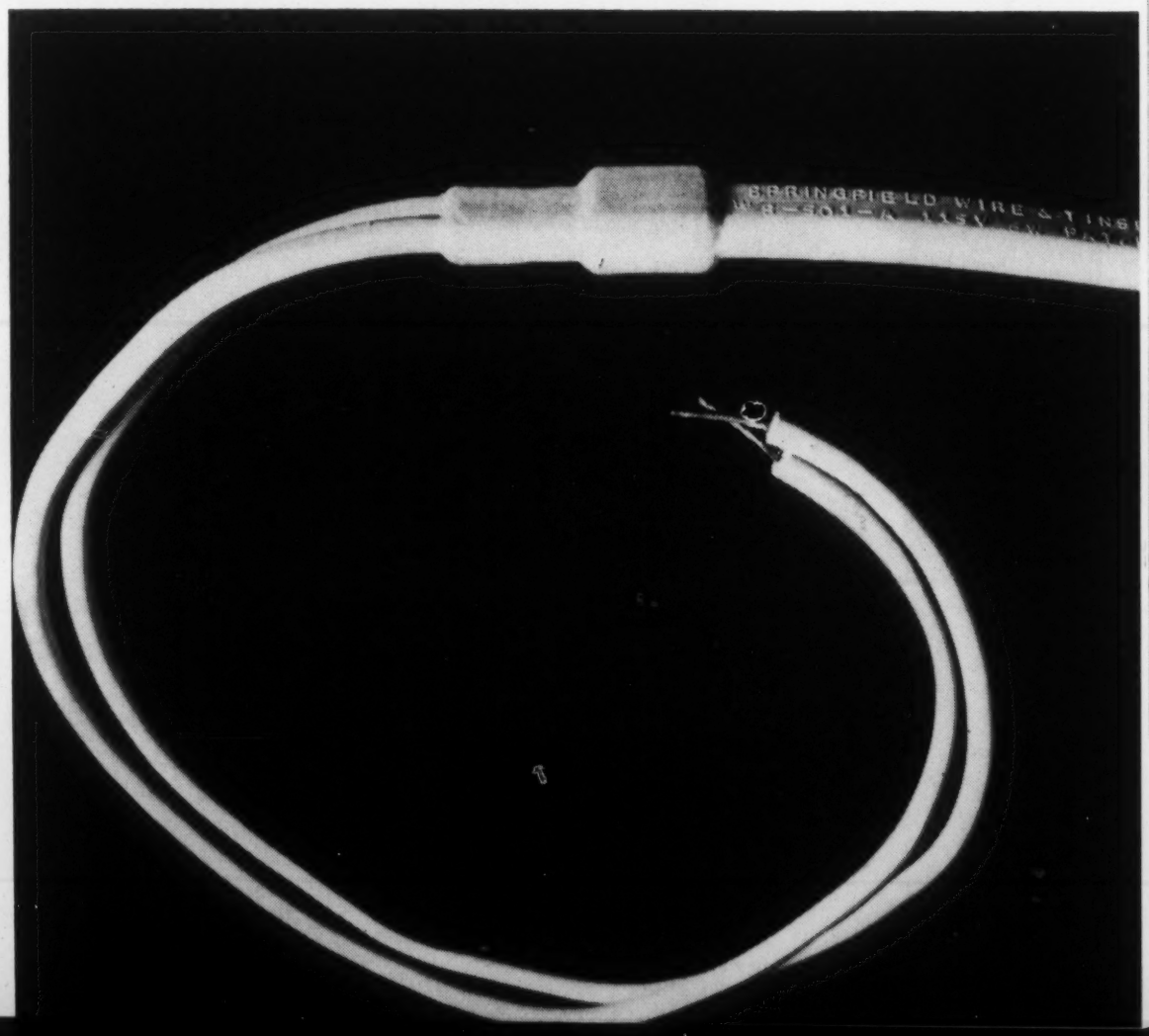
By switching from machined aluminum to die cast zinc and molded nylon, Gries Reproducer Corp. has greatly improved its springbolt for screen windows.

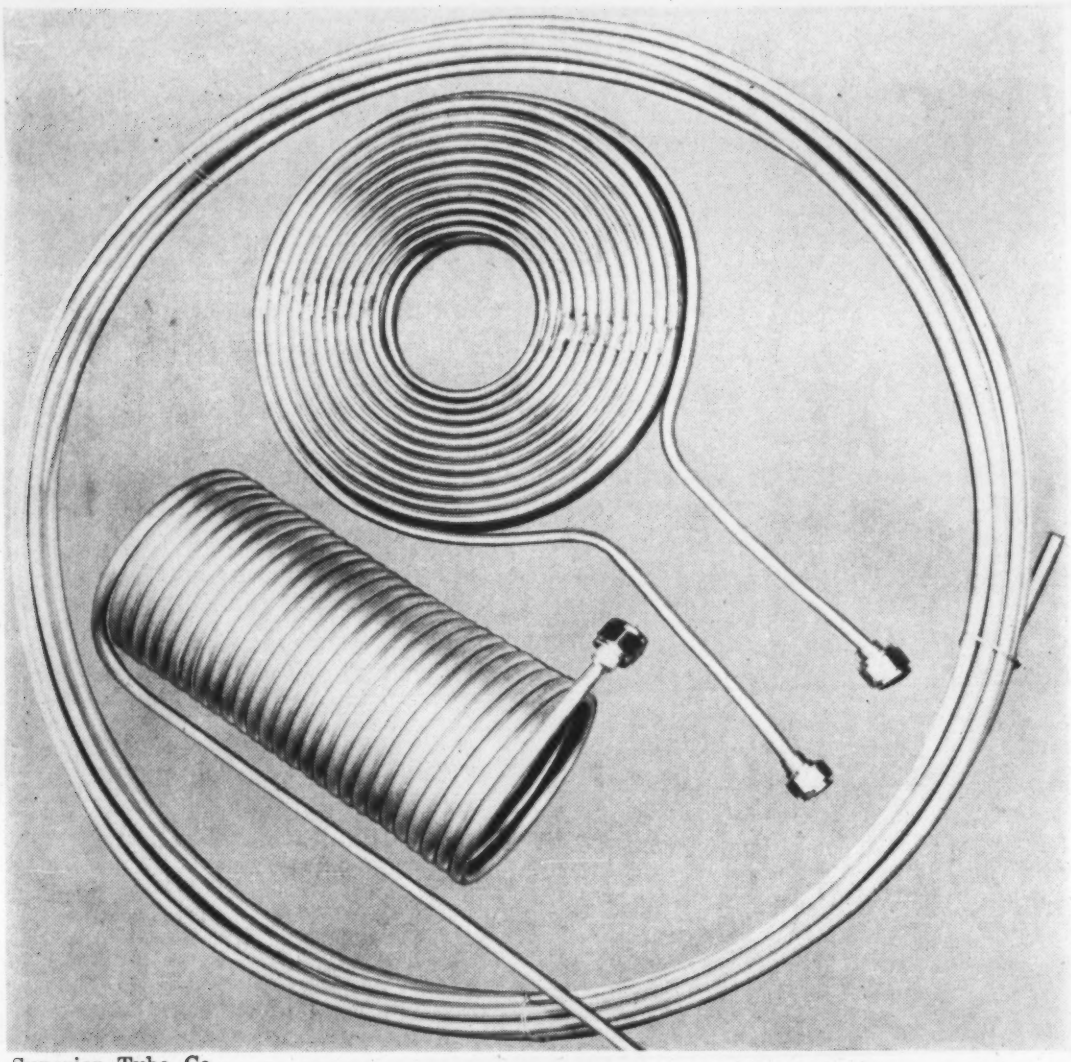
The new bolt is composed of a die cast zinc handle, a cadmium-plated steel spring and a molded nylon cap (see photo). The die cast handle has a thread at one end with two flats formed in the casting operation. This permits the handle to cut its own thread as it is screwed into the nylon cap. The nylon cap, in addition to preventing the spring from slipping, will not mar the sill, may be used on wood sills without a metal receptacle, and will not bind.

Silicone rubber insulation takes lots of heat

The refrigerant tube heater shown here is insulated with two silicone rubber compounds manufactured by General Electric Co. The lead wire is covered with SE-975, a new material claimed to withstand intermittent exposure to temperatures as high as 480 F. The flexible heating element is insulated with SE-740, an electrical grade silicone.

In addition to resistance to heat, the new silicone material has 1150 psi tensile strength, 425% elongation and 125 lb per in. tear strength.





Superior Tube Co.

Various sizes and shapes of coils are . . .

Stainless steel tube replaces block tin pipe

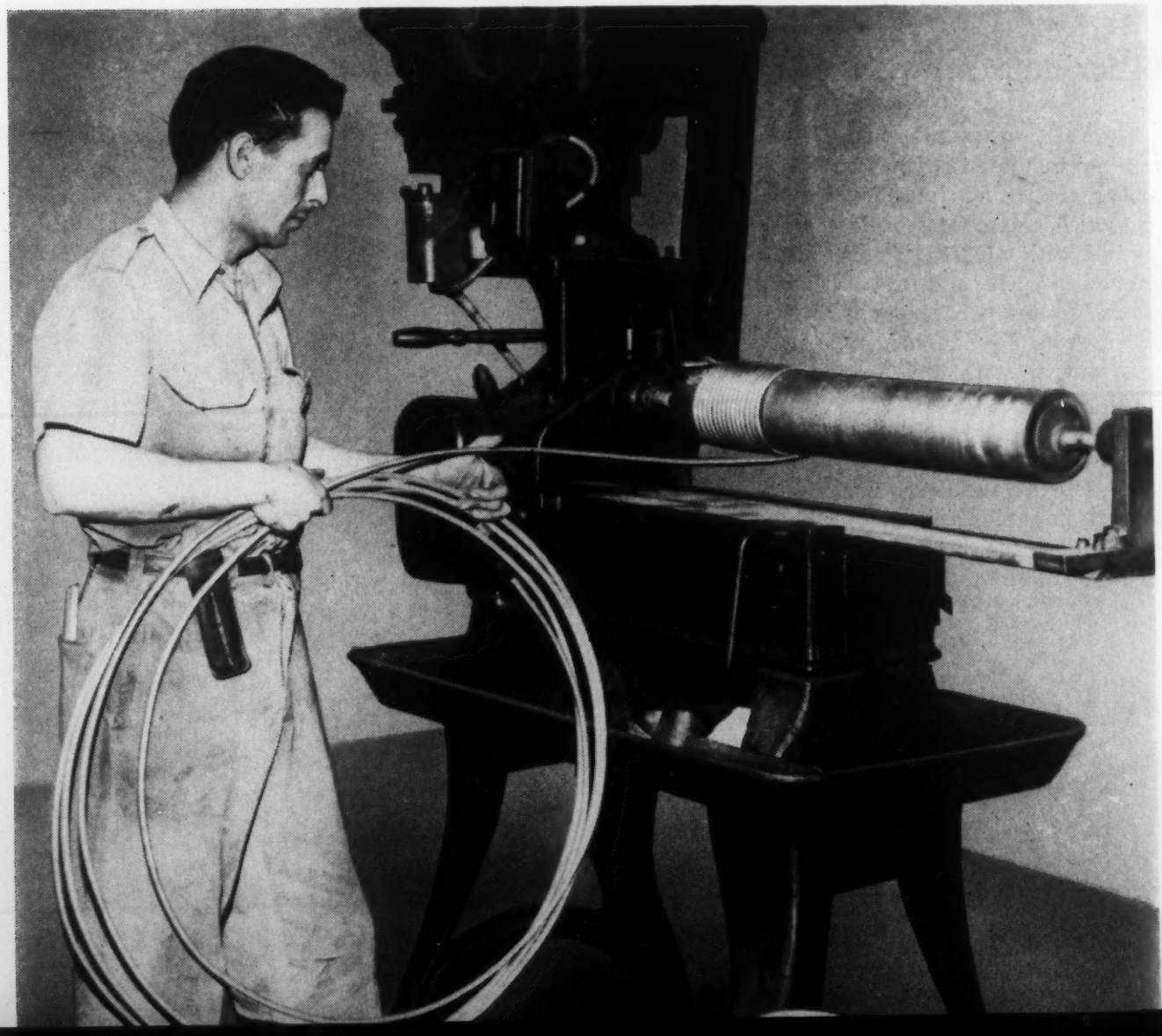
As-welded type 304 stainless steel tubing has replaced block tin pipe for the production of beverage cooling coils at Tap Rite Products.

The stainless steel was the only material found to satisfy the following requirements:

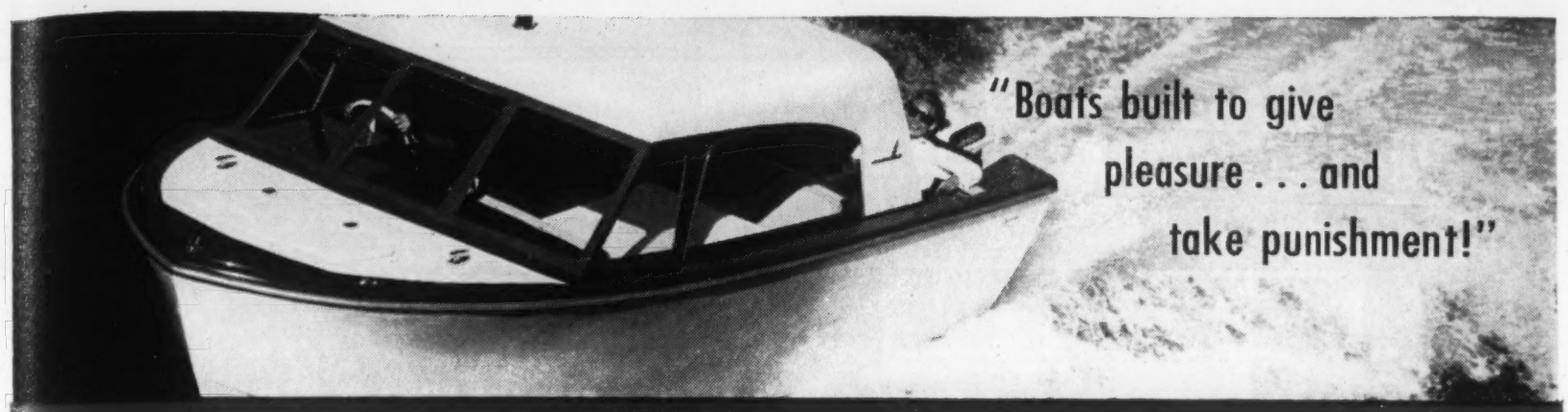
1. The tubing must be furnished in the as-welded condition to keep the cost in line with that of block tin pipe.
2. No filler of flux can be used in the welding since this would impair the tube's resistance to corrosion.
3. The tubing must be hard enough to resist denting or piercing by ice picks but soft enough to be bent, flattened, twisted and formed without danger of reducing the interior diameter or splitting.

The tubing is produced by fusion welding the edges of strip steel. In addition to satisfying the above requirements, the stainless steel tubing is easy to clean, is bright and shiny, and allows thinner walls as a result of its high strength.

. . . produced on this machine.



MATERIALS AT WORK



● Bumps and bruises that would often splinter an ordinary craft are shrugged off by these sturdy boats made with RCI POLYLITE polyester resin. Plastic Fabrications, Inc., Miami, Florida, reports that the inherent resiliency of RCI POLYLITE reinforced with fibrous glass allows a hull to "give" under pressure instead of offering stiff resistance — thus improving the overall strength and safety factor of their products.

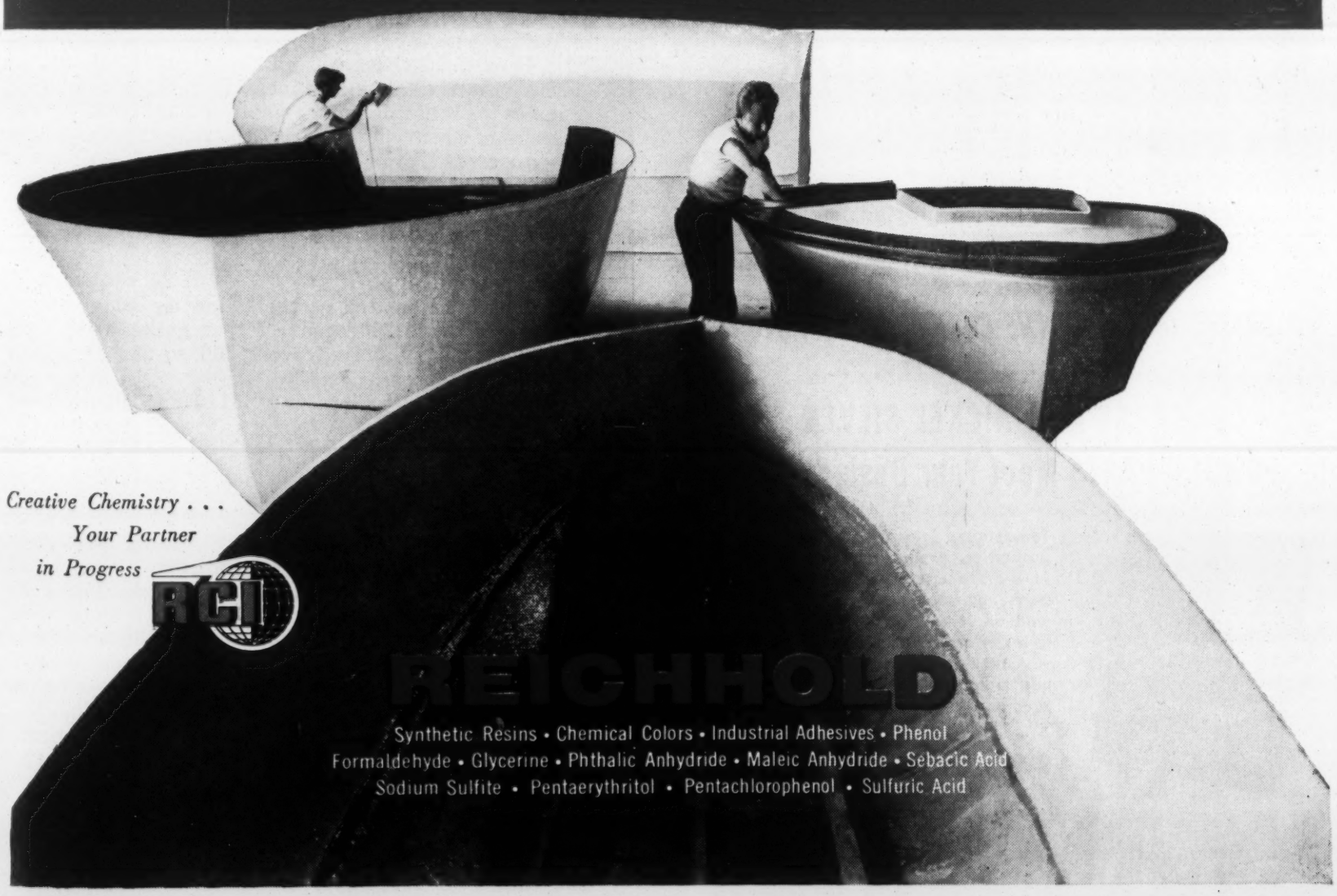
In addition, a molded boat permits more attractive and complicated hull and deck structure — usually expensive features — at reasonable cost . . . and eliminates sharp edges that are dangerous in angry waters.

"In production, our primary requirement is a base material with consistent formulation," says J. A. "Woody" Woodson, Plastic Fabrications' president, in explaining why his firm uses RCI POLYLITE. "The curing and weathering characteristics must not vary from batch to batch. If a resin does not cure, our time and labor is lost and the section must be discarded."

"Another 'plus' for Reichhold POLYLITE," continues Mr. Woodson, "is *dependable* distributor arrangements. Our POLYLITE orders are delivered *on time*, so that costly production delays are a thing of the past."

Products possessing the unique advantages possible with RCI POLYLITE — lightweight strength, durability, and easy maintenance — are becoming increasingly popular and profitable in today's market. For additional information about how RCI POLYLITE can be incorporated into one of *your* products by laminating, molding or other plastic applications, write for free *Booklet A.*

Constructed economically with
UNIFORM QUALITY **POLYLITE** RESINS



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REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

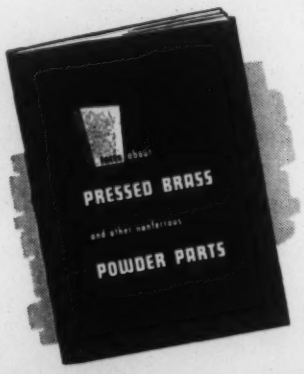
For more information, turn to Reader Service card, circle No. 387

MEETING DESIGN NEEDS
AT LOWER COST
BRASS POWDER
SAVES 92% IN PRODUCING THIS RECORDER PINION GEAR

This gear was formerly machined from pinion stock, involving turning, drilling, cut-off, milling and wire brushing operations. Total cost was 74¢ per gear. As a brass sintering the gear is now pressed into finished shape and size in one operation—plus the addition of flats to the pinion head—at a cost of 5.8¢ per gear—

A SAVING OF 68¢ IN THE COST OF MANUFACTURE.

How Can BRASS AND NICKEL SILVER POWDER PARTS Meet Your Design Needs?



For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 20 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of *your* particular needs.

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Coating prices: a question . . .

To the Editor:

This letter is an inquiry to learn the method of calculation of the data in the column headed "Cost, cents/sq ft/dry mil" of the tabulation captioned "Finishes and Coatings," page 278 of the Apr '57 issue of MATERIALS & METHODS.

I am puzzled why the typical epoxy coating is rated at 2.00 cents and the alkyd-amine (90-10) at 1.75 cents. My impression is that the epoxies by and large are relatively much more costly than an amine-modified alkyd.

NAME WITHHELD BY REQUEST

. . . and an answer

To the Editor:

One of the most popular misconceptions concerning the so-called plastics paints—and perhaps our greatest difficulty in promoting their sale—is the idea that they are far more expensive than ordinary paints.

It is true that, per gallon, epoxies are higher priced than alkyd-melamines. It is also true that epoxies are normally formulated as higher solids, with commensurably greater coverage. The true test of cost is *not* price per gallon, but cost per square foot of coverage per mil thickness applied.

A good quality alkyd-melamine costs about $4.40 per gallon; epoxy-amine costs about $6.00 per gallon. The comparative costs per square foot of coverage per mil applied are 1¾¢ and 2¢ respectively.

This is calculated on the following basis: alkyd-melamine covers 250 square ft per gallon at a 1-mil thickness; epoxy-amine covers 300 sq ft per gallon at 1 mil thickness.

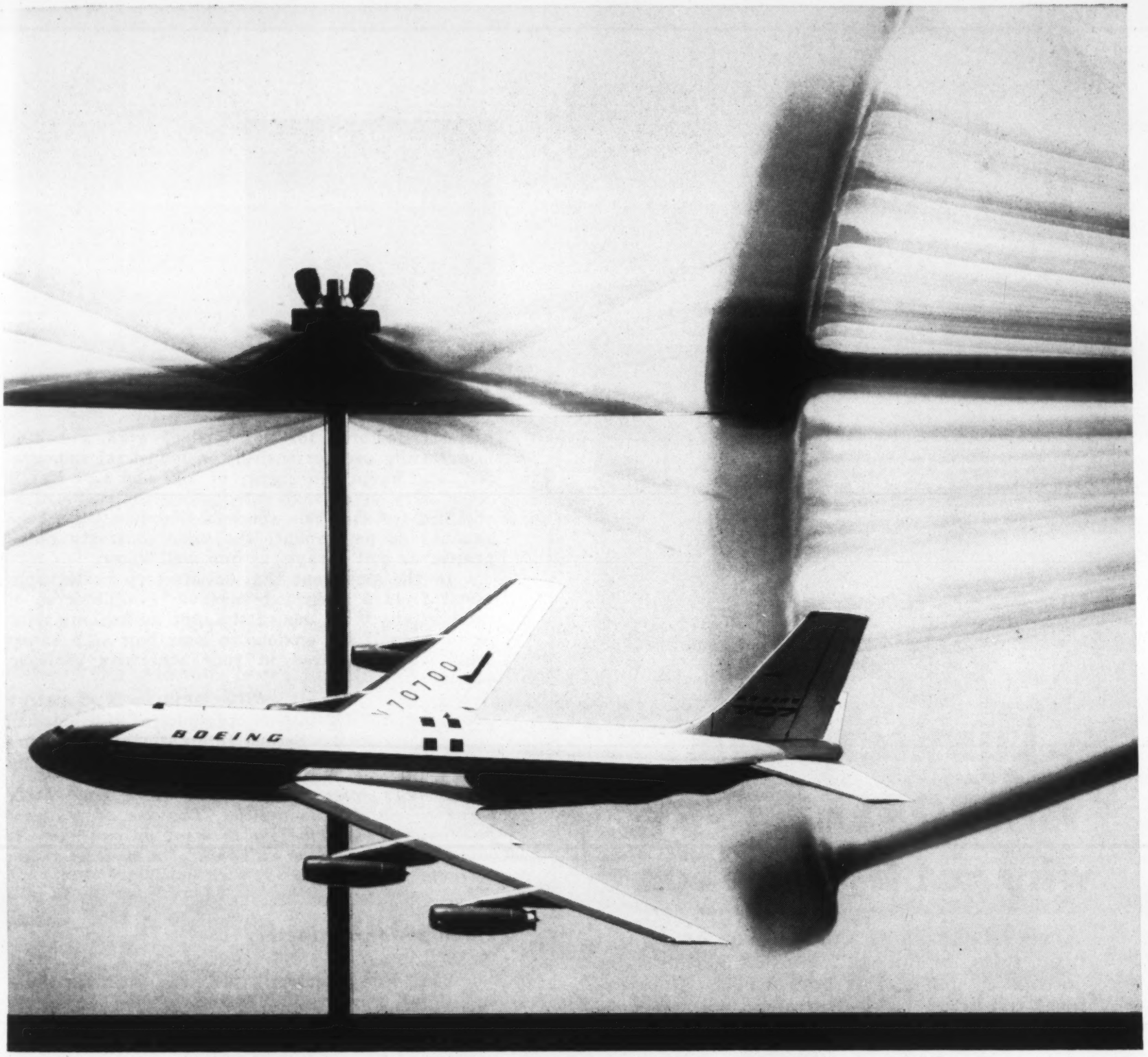
H. R. ROTHENBERG
J. Landau Co.
Carlstadt, N. J.

Radioactive errors

To the Editor:

I would like to comment on some statements made in the article "Radiation Detects Pores in Electroplates" (April, pp 220 and 222) that seem to me to be misleading.

Although I agree fully that soft x-rays have to be used for this type of radiographic inspection, it is difficult for me to understand that radioactive iron (let us assume this refers to iron-59) is being used for this purpose. The half life of this isotope is 45.1 days, and for this reason does not lend itself too well for economic industrial radiographic work. In addition, it emits gammas of 0.191, 1.098 and 1.289 Mev's, which cannot be considered to belong to the family of soft rays. Radioactive nickel-63 is a beta emitter with an energy of 0.067 Mev, and I cannot visualize that this radioisotope can be util-



THERE'S A SOUND REASON FOR HEXCEL HONEYCOMB IN THE BOEING 707

THE PROBLEM: The wing's trailing edges, including control surfaces and tabs, are subject to high sound levels created by the exhausts of powerful jet engines. Ordinary structural materials could not resist damage from these acoustics. **THE SOLUTION:** Hexcel Aluminum Honeycomb with its high, inherent rigidity-to-weight ratio is completely resistant to acoustical bombardment. Boeing designers and engineers, working with research and engineering data supplied by Hexcel's laboratories, were able to build these structures–structures which resist acoustical stress, yet are light weight. The 707's tail surfaces have similar Hexcel Honeycomb parts. Hexcel's research facilities and sales-engineering staff are at the aircraft industry's immediate service.

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letters to the editor

ized satisfactorily for this type of work. Cobalt-60 is naturally used extensively in industrial radiography, and having an energy of 1.17 and 1.33 Mev, I doubt very much that satisfactory contrast can be obtained for such thin specimens because these hard gammas do not produce the same contrasty radiographs as soft x-rays, as you well know.

In the statement that satisfactory radiographs result from a 24-hr exposure to "1 millimicron of radioactivity," the use of the unit millimicron must be in error. I am anxious to hear how such errors could have appeared in your otherwise excellent journal.

DR. GEROLD H. TENNEY
Administrative Chairman
Second International Conference
on Nondestructive Testing

Dr. Tenny's comments are well taken and should serve to clarify the article. The use of the unit "millimicron" is definitely an error on our part. It should have read "one millionth of a curie of radioactivity."

Metal powders directory

To the Editor:

Your File Fact for April was entitled "Metal and Alloy Powders—A Directory." As a leading producer and supplier of tungsten and molybdenum metal powders, the Lamp Wire and Phosphors Dept. of General Electric would like to receive consideration for listing when the Directory is printed again.

Here is the key information concerning our product lines:

Name of Supplier: General Electric Co.
Lamp Wire and Phosphors Dept.
1331 Chardon Rd.
Cleveland 17

Molybdenum: Production method: Hydrogen reduction
Mesh Size (approx): Up to and including 325 (2.5 to 10 microns avg)
Purity: 99.9 min

Tungsten: Production method: Hydrogen reduction
Mesh Size (approx): Up to and including 325 (0.38 to 18.5 microns avg)
Purity: 99.95+

C. W. IRISH
General Electric Co.
Cleveland

We regret the omission and are glad to publish this information.

ONE POINT OF VIEW

Engineers can be ladies

How many women engineers do you know? Chances are that many of you have never seen one. The question is whether this is good or bad. We think it is bad. In recent years a rapidly increasing number of women have entered the other professions and have made many valuable contributions. No comparable increased activity has taken place in the engineering field. This is unfortunate. We think women are a good source of engineering talent and that more of them in engineering work would be an asset to the profession.

No one knows the exact number of women engineers in the United States, but it certainly does not exceed 2000. Chances are that the total is a lot less. The Society of Women Engineers has only about 700 members; and last year only 62 women received engineering degrees. These figures are small indeed when contrasted with the total of 700,000 engineers in the country.

Why more aren't

There are many reasons why women shy away from an engineering career. One of the principal reasons is that the engineering profession always has been regarded as an all-male domain. Consequently, most young women, when choosing a career, never give engineering a thought. And those that do, usually reject engineering because they consider it a rather unattractive, dull profession. They think all engineering involves mechanical drafting or tearing down and testing machines or working around a dirty plant. They are not aware that engineering, like the other professions, is largely intellectual, that it is a broad and versatile field, and that it affords a lot of opportunity to exercise creativeness.

The impression that engineering is only for men is reinforced in many direct as well as subtle ways. Speaking before a recent conference on careers for women, Miss Alva Matthews, an engineer, cited as typical of the attitude toward women engineers the often heard remarks such as: "You can't be an engineer; you can't even repair your own automobile." Some of the other obstacles a girl must overcome on the way to becoming an engineer, she says, are lack of encouragement and sometimes hostility on the part of instructors, and the reluctance of engineer recruiters and companies to hire women engineers.

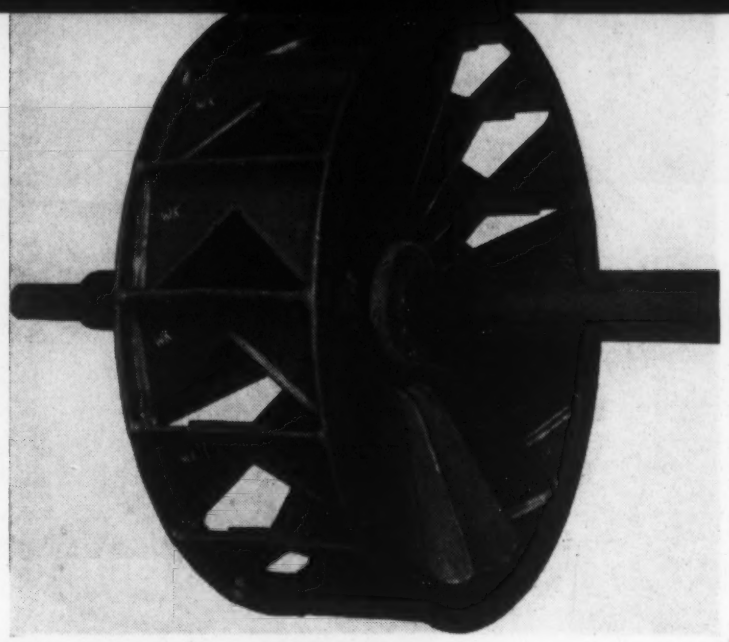
How more could be

There are signs here and there that our ideas about women as engineers are changing. The Canadian Industrial Foundation on Education is making a special study on the best ways to encourage women to enter the field of engineering. In this country, the recommendations of the National Manpower Council call for more effective use of women in the professions, including engineering. And just recently two coeds were awarded highly prized scholarships in the University of Michigan's College of Engineering.

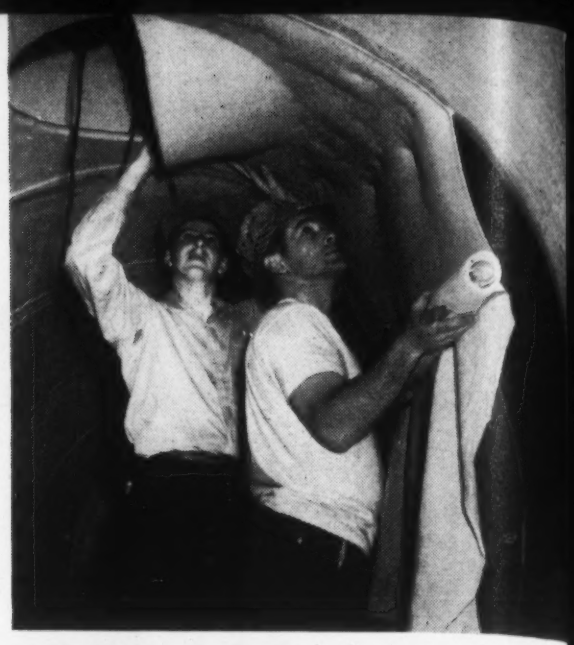
Much more could be done to encourage women to plan careers in engineering. Engineering scholarships could be set up exclusively for girl students. More guidance at the high school level would serve to explain engineering and its opportunities to girls and thus help break down the false prejudices against the profession. And finally, engineers and employers should liberalize their attitude toward women engineers and encourage, rather than discourage, their entrance into a field where there is plenty of room for all—be they male or female.

FEATURE ARTICLES

Where they are used



BLOWER ROTOR



TANK CAR

How to protect metals with Elastomeric Linings

Rugged linings of natural or synthetic rubber —and some plastics—withstand most corrosive chemicals and have long life under severe abrasive conditions.

by L. A. Woerner, *Automotive Rubber Co., Inc.*

■ Because of their resistance to acids, alkalis and strong chemicals, elastomeric materials are widely used as protective linings. The combination of extreme chemical resistance, flexibility and ruggedness obtainable with these materials has made them particularly popular for especially corrosive and heavy duty applications. Natural and synthetic rubber, as well as plastics linings, have a comparatively low over-all cost, are nonconductive and can be formulated so as not to contaminate or discolor solutions. Furthermore, they can be lapped to make strong waterproof joints, and they can be easily patched.

In contrast to coatings and films, which are applied by conventional painting methods, elastomeric linings are applied in much the same manner as wallpaper. Most linings are supplied in heavy sheets, from 3/16 to 1/4 in., and are manufactured by plying 0.20 to 0.30-in. films to the required thickness. Purpose of the plies is to limit any pinholes and abnormalities to one sheet, rather than allow them to extend through the entire thickness of the lining. The linings are usually handled in 48-in. wide rolls 15-25 yd long.

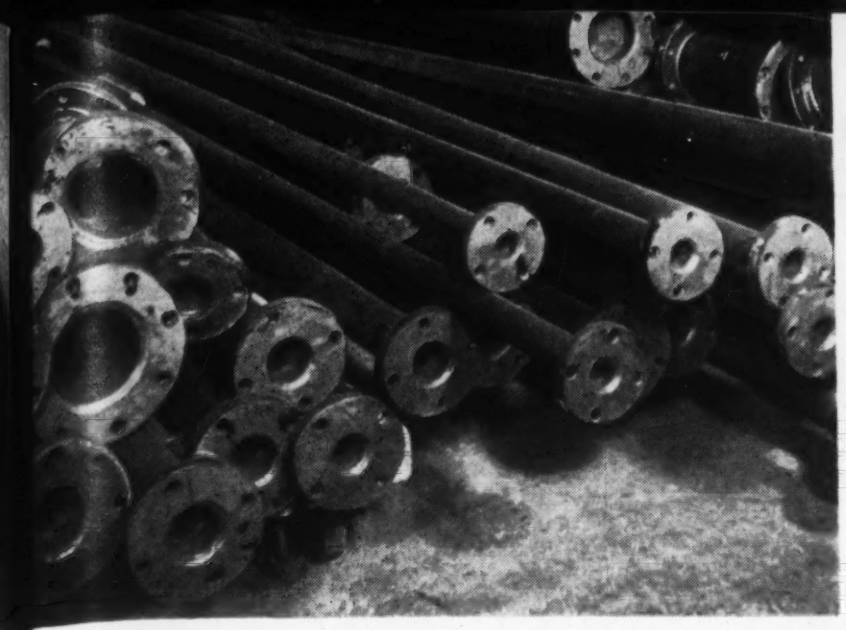
As applied, a complete lining system consists of: 1) a priming cement which provides adhesion to the surface of the basis metal (surfaces must be prepared to accept this cement by sandblasting or other acceptable means); 2) a cement cover coat which provides adhesion both to the primer and to the lining; and 3) the lining itself.

Natural rubber linings

It has been estimated that 70% of all lining materials are made from soft, semihard or hard natural rubber. The soft linings are characterized by high flexibility, toughness and abrasion resistance, and the hard linings by their high chemical resistance. The semihard linings provide a compromise of the best properties of the soft and hard types.

The three types of natural rubber can be distinguished by their sulfur content. Thus, soft rubber has a sulfur content of 2 to 3%; semihard a content of 15 to 30%; and hard rubber 30 to 45%. (In this range hard rubber ceases to be an elastomer and becomes instead a thermoplastic material.) As the sulfur content is increased, chemical resistance at high temperatures also increases, but at the expense of decreased flexibility and increased brittleness. This change in properties is caused by the elimination of chemical and double bonds in the rubber by sulfur cross-linkages.

Semihard rubber—Of the three groups of natural rubbers, the semihard type is probably best suited for general purpose use because: 1) it is comparatively low in cost; 2) it is easily processed and can be built up into 6 or 8-ply sheets that are absolutely free of pinholes; 3) it can be stored almost indefinitely; and 4)



PIPE

PLATING TANK

it can be easily applied and cured.

In addition to the above, semihard rubber can be used in contact with an extremely wide range of chemicals in water solution. Because of its chemical resistance and nonconductivity, it can be used for practically all plating solutions, excepting silver and chromium. It can also be used with aqueous boiling solutions and will withstand a limited number of paraffin oils, greases, kerosene and other aliphatic hydrocarbons at moderate temperaatures. Semihard rubber, however, will not withstand aniline, benzene, carbon disulfide, carbon tetrachloride and other chlorinated hydrocarbons, concentrations of nitric acid greater than 10%, or concentrations of sulfuric acid greater than 50%.

Despite its strength, semihard rubber loses its flexibility at low temperatures. This factor can be detrimental if there is any substantial contraction or expansion of the base structure during temperature cycling. For this reason, a soft lining, soft-hard-soft combination, or a synthetic lining such as neoprene, nitrile or butyl rubber, or Hypalon (chlorosulfonated polyethylene) is preferred at low temperatures. Also, the semihard linings have only fair abrasion resistance, and a soft or synthetic lining may prove more suitable for abrasive slurries and high dust concentrations.

Sandwich linings — Sandwich constructions are often used to obtain a range of properties not obtainable in a single lining material. These composites are made either by sandwiching a sheet of semihard rubber between layers of soft rubber, or by sandwiching a layer of soft rubber between two layers of semihard rubber. In the latter case, the semihard rubber provides chemical resistance, and the soft rubber provides resistance to mechanical shock and temperature cycling.

The coefficient of thermal expansion is about 50-110 x 10^{-6} for soft rubber and 15-40 x 10^{-6} for hard rubber. Comparing these values with 12 x 10^{-6} for mild steel and 6 x 10^{-6} for wood, it can be seen that the linings can expand and contract considerably more than the base material. For example, the side of a 34-ft steel tank car will contract about 0.4 in. between 70 and 0 F. Over this same range the linings want to contract about 2.5 in.—a difference of more than 2 in. At the low temperature, a hard or semihard lining will break at either the joints or corners of the car or at laps in the lining. Failure at high temperatures is not prevalent because of the improvement in elongation properties of these materials when hot.

Sandwich linings are not a cure-all for all applications. In transportation equipment, where there is liable to be extreme flexing of the lining, cracks may develop in the semihard layer of the lining and destroy its effectiveness. Thus, the protective burden is thrown on the soft layer(s). There is also the hazard of ply separation occurring at the interface of soft and semihard rubber because of the differential in swelling from solution pickup.

Synthetic elastomer linings

Neoprene—For a given thickness, neoprene linings are more costly than natural rubber linings. However, the heat resistance of neoprene is much better than that of soft natural rubber, and the material is well suited for use above 150 F with the general run of chemicals. Compared to nitrile rubber, neoprene is lower in cost, has somewhat better chemical resistance and is easier to apply.

Neoprene linings are especially noted for their resistance to caustics, fluorides, ammonium nitrate, fatty acids, greases, oils and other aliphatic hydrocarbons. Hydrochloric acid and pressurized anhydrous ammonia will slowly penetrate a neoprene lining.

Nitrile rubber—Linings of this

Pick the Right Lining

There are many types of elastomers, each with its own particular properties. The extensive tabular data on the next two pages will help you choose the right one.

S=Satisfactory Q=Questionable

	Temp, F[a]	Natural Rubber	Neoprene	Hypalon	Nitrile Rubber	Polyvinyl Chloride
Inorganic Acids[b]						
Arsenic	150	S	S	CS	CS	S
Boric	150	S	S	S	CS	S
Carbonic	90	S	S	CS	CS	S
Chromic (50%)	70	NR	NR	S	CS	S
Fluoboric	150	S	S(40%)	S	CS	S
Fluosilicic	150	S	S	S	CS	S
Hydrobromic	150	S	S	S	CS	S
Hydrochloric	150	S	NR	S	S(20%)	S(35%)
Hydrocyanic	150	S	S	S	CS	CS
Hydrofluoric						
4%	150	S	CS	S	CS	S
50%	70	S[d]	NR	S	CS	S(48%)
Nitric						
10%	70	S	S	S	NR	S
35%	70	NR	NR	CS	CS	S
70%	70	NR	NR	Q	CS	CS
Perchloric	120	S	S(10%)	CS	CS	S
Phosphoric (85%)	150	S	S	S	S(40%)	S
Sulfuric						
50%	150	S	S	S	S(30%)	S
95%	150	NR	NR	S	CS	CS
Sulfurous	125	S	S	CS	CS	S(90 F)
Inorganic Alkalis[b]						
Amonium Hydroxide	100	S	S	S	S	S
Barium Hydroxide	150	Q	S	S	CS	CS
Calcium Hydroxide	150	Q	S	S	S	CS
Magnesium Hydroxide	150	S	S	S	CS	CS
Potassium Hydroxide	150	S	S	S	S(30%)	S(35%, 90 F)
Sodium Hydroxide	150	S	S	S	S(50%)	S(35%, 90 F)
Inorganic Salts and Compounds[b]						
Alums						
Amonium	150	S	S	S	S	S
Chromium	150	S	S	S	CS	S
Potassium	150	S	S	S	CS	S
Aluminum						
Acetate	150	S	CS	CS	CS	CS
Bromide	150	S	CS	CS	CS	CS
Chloride	150	S	S	S	CS	S
Fluoride	150	S	S	S	CS	Q
Nitrate	150	S	CS	CS	CS	S
Sulfate	150	S	S	S	CS	S
Ammonia						
Liquid	—	S	S	S	S	CS
Gas	—	S	S	S	CS	CS
Amonium						
Acetate	150	S	S	CS	CS	S
Carbonate	150	S	S	CS	NR	S
Chloride	150	S	S	S	CS	S
Dichromate	150	S	S	CS	CS	S
Nitrate	150	S	S	S	S	S
Persulfate	150	S	S	CS	CS	S
Phosphate	150	S	S	S	CS	S
Sulfate	150	S	S	S	CS	S
Barium						
Chloride	150	S	S	S	CS	CS
Nitrate	150	S	S	CS	CS	CS
Sulfide	150	S	S	S	S	S
Bleach Solutions	150	S	CS	CS	CS	Q
Borax	150	S	S	S	CS	S
Brine (chlorinated)	150	S	CS	CS	CS	S(90 F)
Bromine	70	NR	NR	NR	CS	CS
Calcium						
Acetate	150	CS	CS	CS	S	CS
Bisulfite	70	S	S	S	CS	Q
Carbonate	150	S	S	CS	CS	CS
Chloride	150	S	S	CS	S	S
Sulfate	150	S	S	CS	CS	S
Carbon Dioxide	—	S	S	S	CS	CS

	Temp, F[a]	Natural Rubber	Neoprene	Hypalon	Nitrile Rubber	Polyvinyl Chloride
Inorganic Salts and Compounds (cont'd)						
Carbon Monoxide	—	S	S	S	CS	CS
Chlorine						
Dry	70	S[c]	Q	Q	CS	Q
Wet	100	S[c]	NR	NR	CS	Q
Chlorine Dioxide (0.2%)	70	NR	NR	S	CS	CS
Copper						
Chloride	150	S	S	CS	CS	S
Cyanide	150	S	S	CS	CS	S
Sulfate	150	S	S	CS	S	S
Developing Solutions	150	S	CS	CS	CS	S
Epsom Salts	150	S	CS	CS	CS	CS
Ferric						
Chloride	150	S	S	S	CS	S
Nitrate	150	S	S	S	CS	CS
Sulfate	150	S	S	S	CS	S
Ferrous						
Sulfate	150	S	S	CS	CS	S
Chloride	150	S	CS	CS	CS	CS
Glauber's Salt	150	S	CS	CS	CS	S
Hydrogen						
Peroxide (3%)	70	S	S	S(88%)	S(30%)	S(30%)
Sulfide	150	S	S	S	CS	S
Hypo Solutions	150	S	CS	CS	CS	S
Iodine	—	NR	Q	S	CS	CS
Lead						
Acetate	150	S	S	CS	CS	S
Nitrate	150	S	CS	CS	CS	CS
Lime						
Bleach	90	S	CS	CS	CS	S
Water	150	S	CS	CS	CS	S
Lye Solution	150	S	CS	CS	CS	Q
Manganese Sulfate	150	S	S	CS	CS	S(10%)
Magnesium						
Chloride	150	S	S	S	S	S
Sulfate	150	S	S	S	CS	S
Mercury	—	S	S	S	CS	CS
Mercuric Chloride	150	S	S	S	CS	CS
Nickel						
Acetate	150	S	S	S	CS	S
Chloride	150	S	CS	CS	CS	S
Sulfate	150	S	CS	CS	CS	S
Nitre Cake	150	S	CS	CS	CS	S
Potassium						
Acid Sulfate	150	S	CS	CS	CS	S
Bisulfate	150	S	S	CS	CS	S
Carbonate	150	S	S	CS	CS	S
Chloride	150	S	S	S	S	S
Cyanide	150	S	S	S	CS	S
Dichromate	150	Q	S	S	CS	S
Sulfate	150	S	S	S	CS	CS
Sulfide	150	S	S	CS	CS	S
Sulfite	150	S	S	CS	CS	CS
Thiosulfate	150	S	S	CS	CS	S
Silver Nitrate	150	S	S	CS	CS	CS
Sal Ammoniac	150	S	CS	CS	CS	S
Sea Water	150	S	CS	CS	CS	S
Sodium Salts (see Potassium Salts)						
Sodium Bicarbonate	150	S	S	CS	CS	S
Sodium						
Peroxide	150	Q	S	S	CS	CS
Perborate	150	S	CS	CS	CS	CS
Phosphate	150	S	S	CS	CS	S
Sulfate Liquor						
Black	150	S	S	S	S	S(90 F)
Green	—	S	S	S	CS	CS
Sulfite Liquor	150	S	CS	CS	CS	CS
Sulfur	70	S	S	S	CS	CS
Sulfur						
Chloride	70	S	S	S	CS	CS
Dioxide (liquid)	70	S[c]	S	S	CS	CS
Dioxide (water)	90	S	CS	CS	CS	S

[a]Max temp at which tests have been conducted. Values may or may not represent max temp at which materials will resist attack, or max temp at which the lining or its adhesive will resist mechanical failure.

material are used in applications where the solvent or heat resistance of neoprene or natural rubber is questionable. These applications are not numerous, however, because of nitrile's comparatively high cost and the fact that natural rubber and neoprene will handle almost any chemical solution that nitrile will. Some hydrocarbons which neoprene is not recommended for, but which can be handled by nitrile rubber, are: carbon disulfide, toluene, xylene, turpentine and acetaldehyde.

Butyl rubber—Butyl rubber is relatively new as a lining material and can be compounded to

ELASTOMERIC LININGS

NR=Not Recommended CS=Check with Supplier

	Temp, F[a]	Natural Rubber	Neoprene	Hypalon	Nitrile Rubber	Polyvinyl Chloride
Inorganic Salts and Compounds (cont'd)						
Sulfur (cont'd)						
Trioxide (gas)	70	NR	NR	Q	CS	CS
Tin (stannic chloride)	150	S	S	S	CS	S
Tin (stannous chloride)	150	S	S	CS	CS	S
Zinc Chloride	150	S	S	S	S	S
Zinc Sulfate	150	S	S	S	S	S
Organic Compounds[b]						
Acetaldehyde	70	NR	CS	CS	NR	NR
Acetic Acid						
25%	150	S[c]	S	S	CS	S(10%, 70 F)
Glacial	70	S[c]	Q	Q	NR	NR
Anhydride	70	S[c]	S	S	NR	NR
Acetone	70	S	Q	Q	NR	NR
Acetylene	—	NR	Q	Q	Q	Q
Alcohol						
Amyl	150	S	S	S	CS	S(90 F)
Butyl	150	S	S	S	S	S(90 F)
Diacetone	150	Q	S	S	CS	CS
Ethyl	150	S	S	S	S	S(90 F)
Isobutyl	150	S	CS	CS	CS	CS
Isopropyl	150	S	CS	CS	CS	CS
Methyl	70	S	S	S	S	S(90 F)
Propyl	150	S	S	S	S	S(90 F)
Amyl Acetate	70	NR	NR	NR	NR	CS
Aniline Oil	70	S[c]	NR	NR	NR	CS
Aniline Dyes	150	Q	Q	Q	CS	CS
Asphalts	150	NR	Q	Q	CS	CS
Beer	150	S	S	S	CS	S
Beet Sugar Liquors	150	S	S	S	CS	CS
Benzene	150	NR	NR	NR	CS	NR
Benzoic Acid	150	S	S	CS	CS	S
Benzaldehyde	70	NR	NR	NR	NR	CS
Bleach Liquor	150	S	CS	CS	CS	Q
Butadiene	70	NR	NR	NR	CS	CS
Butane	70	NR	S	S	S	CS
Butter	100	NR	S	S	CS	CS
Butyl Acetate	70	NR	NR	NR	NR	CS
Cane Sugar Liquors	150	S	CS	CS	CS	CS
Carbolic Acid (phenol)	150	NR	NR	NR	NR	NR
Carbon						
Bisulfide	70	NR	NR	NR	S	NR
Tetrachloride	70	NR	NR	NR	S	NR
Chlorosulfonic Acid	70	NR	NR	NR	CS	CS
Chlorinated Solvents	70	NR	NR	NR	CS	CS
Chloroacetic Acid	70	NR	S	S	CS	CS
Chloroacetone	70	S	NR	S	CS	CS
Chloroform	70	NR	NR	NR	NR	CS
Citric Acid	125	S	S(10%, 85 F)	S	S	S
Cod Liver Oil	70	NR	S	S	CS	CS
Corn Oil	70	NR	S	S	CS	CS
Cotton Seed Oil	150	S[c]	S	S	S	S(90 F)
Creosote	70	NR	NR	NR	CS	NR
Cresol	70	NR	NR	NR	NR	CS
Cyclohexane	70	NR	NR	NR	CS	CS
Cyclohexanone	70	NR	NR	CS	CS	NR
Dibutyl Ether	70	NR	NR	NR	CS	CS
Dowtherm	70	NR	NR	NR	NR	CS
Ethers	70	NR	S	S	S	CS
Ethyl Acetate	70	NR	NR	NR	NR	CS
Ethyl Benzene	70	NR	NR	NR	NR	CS
Ethyl Cellulose	70	S	S	S	CS	CS
Ethyl Chloride	70	NR	NR	NR	NR	CS
Ethylene Dichloride	70	NR	NR	NR	CS	CS
Ethylene Glycol	150	S	S	S	S	S(90 F)
Fatty Acids	150	NR	S	S	CS	CS
Formaldehyde	70	S	S	S	S	CS
Formic Acid	100	S	S(90 F)	S	S	Q
Fruit Juices	70	Q	CS	CS	CS	CS
Organic Compounds (cont'd)						
Fuel Oil	70	NR	S	S	CS	CS
Fumaric Acid	70	S	CS	CS	CS	Q
Furfural	100	S[c]	Q	Q	NR	CS
Gallic Acid	150	S	S	CS	CS	S
Gasoline	77	S[c]	Q	NR	S	S
Glucose	150	S	S	S	CS	S
Glue	150	S	S	S	CS	S
Glycerine	150	S	S	S	S	S(90 F)
Grease	70	S[c]	Q	Q	CS	CS
Heptane	70	NR	S	S	CS	CS
Hexane	70	NR	S	S	S	CS
Hydraulic Oil	70	CS	CS	CS	S	CS
Hydroquinone	70	S[c]	S	S	CS	S(90 F)
Isododecane	70	NR	S	S	CS	CS
Isooctane	70	NR	S	S	CS	CS
Isopropyl Ether	70	NR	NR	NR	CS	CS
Kerosene	70	S[c]	Q	Q	S	CS
Lactic Acid	150	S	S	S	CS	S(90 F)
Lacquers	70	NR	NR	NR	CS	CS
Lard	70	NR	S	S	CS	CS
Lead Sulfamate	70	S	S	S	CS	CS
Linseed Oil	70	NR	S	S	S	CS
Lubricating Oils	70	NR	Q	Q	CS	CS
Maleic						
Acid	150	S	CS	CS	CS	CS
Anhydride	150	S	CS	CS	CS	CS
Malic Acid	150	S	CS	CS	CS	S(90 F)
Methyl Cellosolve	150	NR	S	S	CS	CS
Methylene Chloride	70	NR	NR	NR	CS	CS
Milk	100	NR	S	S	CS	CS
Mineral Oil	70	S[c]	S	S	CS	S(90 F)
Naphtha	70	NR	NR	NR	S	CS
Naphthalene	70	NR	NR	NR	NR	CS
Nitrobenzene	70	NR	NR	NR	CS	CS
Oleic Acid	150	NR	S	CS	S	S(90 F)
Olive Oil	150	NR	S	S	CS	CS
Oxalic Acid	150	S	S	S	CS	S(90 F)
Oxygen	70	S	S	S	CS	CS
Palmitic Acid	150	Q	Q	Q	CS	CS
Petroleum Oils	70	NR	Q	Q	CS	CS
Picric Acid	70	S	S	S	CS	CS
Pine Oil	70	NR	NR	NR	NR	CS
Propane	70	NR	Q	Q	CS	CS
Salicylic Acid	150	S	CS	CS	CS	CS
Soap Solution	70	Q	S	S	CS	S
Soy Bean Oil	70	NR	S	S	CS	CS
Stearic Acid	70	Q	Q	Q	S	CS
Sugar	150	S	CS	CS	CS	CS
Tannic Acid	150	S	S(60%)	S	CS	S
Tar	70	CS	S	S	CS	CS
Tartaric Acid	150	S	S(60%)	S	CS	S
Toluol	70	NR	NR	NR	NR	CS
Tributyl Phosphate	70	NR	NR	S	CS	CS
Trichloroethylene	70	NR	NR	NR	NR	CS
Tung Oil	70	NR	S	S	CS	CS
Turpentine	70	NR	NR	NR	S	CS
Vegetable Oils	70	Q	S	CS	CS	Q
Vinegar	150	Q	S	S	CS	S
Whiskey and Wine	90	S	S	S	CS	S
Xylol	70	NR	NR	CS	NR	NR
Zeolites	150	S	CS	CS	CS	S
Plating Solutions						
Brass, Cadmium, Copper (acid and cyanide), Gold (cyanide), Indium, Lead, Nickel (gray and bright), Rhodium, Silver, Tin, Zinc.	150	S	S	CS	CS	S
Chromium	150	NR	NR	CS	CS	S

[b]For all concentrations except where indicated. Percentages given are by weight. [c]Hard rubber only.

give better heat and oxidation resistance than soft natural rubber. Butyl linings have been used in such corrosive media as: 50% (200 F) and 70% (140 F) sulfuric acid; 20% (180 F) and 30% (160 F) nitric acid; and 60% hydrogen fluoride at 180 F.

Butyl rubber can handle the whole range of aqueous chemical solutions, excepting possibly hydrochloric acid, and it resists attack by vegetable and animal oils. To date, application of the material has been delayed because of curing problems at low temperatures. However, formulations are now available that show excel-

lent cure with atmospheric steam.

Hypalon—Hypalon linings are relatively new and hold a great deal of potential because of their excellent chemical and oxidation resistance and their flexibility at high temperatures. The material has good resistance to oil and solvents, hydrogen peroxide (50%), phosphoric acid to 85%, sulfuric acid to 50%, and sodium and potassium hydroxide to 50%. Also, at 158 F it resists nitric acid to 20%, hydrofluoric acid to 48% and sulfuric acid to 80%. Higher concentrations of these chemicals and a host of other chemicals can, of course, be tolerated at room temperatures.

Hypalon linings are manufactured and applied by regular lining methods. The linings have a good appearance, excellent adhesion to steel, and cohesion in lapped joints.

PVC linings

By definition, PVC (polyvinyl chloride) is not an elastomeric material. Because of its properties, however, PVC is competitive with elastomeric materials and is used in specialized lining applications.

These linings are unusually resistant to nitric and chromic acids. For this reason, they are widely used in pickling baths for stainless steel (20% nitric acid and 4% hydrogen fluoride at 140 F) and in chromium plating baths (48 oz chromic oxide per gal at 160 F). Because of limitations of their adhesives, PVC linings are limited to service below 150-180 F. In some applications higher temperatures can be tolerated if the lining is backed with an acid resistant carbon brick, which serves to reduce the temperature at the face of the lining.

PVC linings are not presently recommended for outside tanks (including railroad and truck tanks) where the temperature rise in the base structure could rise above the temperature the adhesives will withstand. This condition is expected to be remedied as new adhesives, now available from research laboratories, are put into use. These adhesives possess a peel strength of about 30 lb per in. width and maintain their bond strength above 220 F.

Temperature limitations

The factor of operating temperatures is especially important in selecting a lining material. In addition to affecting the internal structure of the lining material itself, high temperatures also accelerate the rate of chemical reaction between the liquid and the lining.

If the general rule is applied that the rate of chemical reaction doubles every 18 deg F, we find that a given rate of reaction at 70 F increases 4 times at 106 F, 32 times at 160 F and 128 times at 200 F. These temperature increases may also be accompanied by an increase in lining permeability. The calculations assume that no reaction products are formed to slow down or stop the reaction.

The physical and mechanical limits of the various lining materials are reached at about the following temperatures. (It is especially important to note that these values do not take into account any changes in properties resulting from increases in the rate of chemical attack or permeability as temperature rises.

Soft natural rubber	160 F
GR-S	160 F
Polyvinyl chloride	190 F
Semihard natural rubber	212 F
Hard natural rubber	220 F
Butyl rubber	220+ F
Neoprene	250+ F
Nitrile rubber	300+ F
Hypalon	350 F
Silicone rubber	500 F

In many applications temperatures of the linings can be reduced considerably by using some form of thermal insulation.

At low temperatures (i.e., about freezing or below), the rate of chemical attack tends to be less of a design factor, and emphasis shifts mainly to the physical and mechanical properties. Following are the temperatures at which the physical and mechanical properties of the materials become questionable:

Hard natural rubber	+35 F
Semihard natural rubber	+30 F
Polyvinyl chloride	—
Hypalon	–25 F
Neoprene	–40 F
Nitrile rubber	–60 F
Butyl rubber	–70 F
Silicone rubber	–70 F
GR-S	–80 F
Soft natural rubber	–80 F

Cost

Since a considerable part of a lining's cost is made up of costs involved in handling, surface preparation, and application and curing, it is easy to understand why the price of a lining is not directly proportional to its thickness. A 3/16-in. lining of natural rubber gives adequate protection for most applications and costs in the range of $3.00 per sq ft. Where service is questionable, ¼-in. linings or double 3/16 or ¼-in. linings are often applied.

The approximate costs of 3/16-in. synthetic rubber and plastics linings (per sq ft) are: neoprene, $3.25; nitrile rubber, $3.25; Hypalon, $3.40; and PVC, $3.40 ($3.25 for a 3/32-in. lining). These prices appear high when compared with those of conventional coatings. However, the linings can be expected to remain trouble-free for years, and maintenance and production downtimes are extremely low.

TYPICAL PROPERTIES OF LINING MATERIALS

Type →	Natural Rubber			Neoprene	Hypalon
	Soft	Semihard	Hard		
Hardness (Shore A Durometer)	35±3	95±2	80 (D scale)	65±3	70±3
Tensile Strength, psi	2800	1900	1800	1800	1800
Elongation, %	750	175	<0.2	375	260
Cure	45 min at 275 F	50 min at 285 F	60 min at 390 F	60 min at 275 F	30 min at 310 F

Freight car wheel *sectioned to show chilled zone. Brinell hardness: white iron section, 400-415; mottled zone, 172-183; gray iron section, 165.*

Severe Abrasion? Try White or Chilled Cast Iron

These widely used castings, produced by adjusting composition and solidification rate, have extremely hard surface plus controllable core properties.

■ White and chilled iron castings, although they may be similar in composition, have properties that differ from those of the more familiar gray iron castings. These property changes result from a change in metallurgical structure.

White iron castings are produced by controlling the composition and rate of solidification so that virtually all of the carbon exists in the combined form as carbide. This combined carbon makes the iron hard and wear resistant, with high compressive strength, but low in impact resistance and machinability. Impact resistance may be less than one-third that of gray iron. The metal is called white cast iron because of the characteristic white appearance of a fractured surface. Alloying additions change structure and improve properties for many applications.

Chilled iron castings are composite gray and white irons produced by casting iron of suitable composition against metal or graphite chills imbedded in sand molds, or by casting in molds made entirely of metal. Iron cast near the chill surfaces solidifies rapidly and becomes white iron; metal away from the chill solidifies more slowly and becomes gray iron. A mottled iron may be formed in an intermediate zone between the white and gray irons.

The unalloyed grades of white or chilled iron are used for various abrasion resistant purposes, the moderately alloyed grades for wear resistance, and the highly alloyed grades for heat, abrasion and corrosion resistance.

In general, unalloyed or low alloy white or chilled irons may be more economical for applications in which the wear is caused by another surface or the abrasion of relatively large-sized materials. Where the casting is subjected to wear or erosion on a microscopic basis by the action of very fine abrasive materials, such as slurries, the use of a medium or high alloy iron that has a microstructure of carbides and martensite will probably be preferable. It should be recalled that wear resistance is primarily a condition of service, rather than the property of a material, and the problem of material selection is often complicated by other factors such as corrosion or cavitation.

Properties

Some physical and mechanical properties of various grades of white and chilled iron are given in a table on the next page.

In unalloyed chilled irons the hardness, strength and depth of the white iron layer is regulated by composition, particularly carbon content, and by casting conditions. Maximum hardness is obtained with a high carbon content; lower hardness with improved strength and shock resistance is obtained with a lower carbon content. Brinell hardness can range from 575 for the higher carbon iron to 1350 for the lower carbon variety. However, the low carbon iron may have a tensile strength of 50,000 psi, whereas the high carbon iron has a strength of only 30,000 psi.

Small additions of nickel, chromium, copper and molybdenum, singly or in combination, are fre-

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Adapted from a section on the properties of white and high alloy cast irons, by J. H. Culling, vice president, Carondelet Foundry Co., St. Louis; and Prof. John F. Wallace, Case Institute of Technology, Cleveland, to be included in the Gray Iron Founders' Society's forthcoming *Iron Castings Handbook*, edited by Charles F. Walton.

quently made to unalloyed chilled or white irons to improve their properties. In these low alloy irons, combinations of nickel and chromium or nickel and copper can be adjusted to control chill depth and increase hardness, strength or service life. Small additions of chromium and molybdenum improve hardness, strength and chill depth. Additions of up to 1.5% chromium alone or in combination with up to 2.5% nickel, 0.6% molybdenum or 0.2% vanadium have greatly improved the service life of white and chilled irons.

Addition of 3 to 5 nickel and 1.5 to 3.5% chromium produces a white iron (Ni-Hard) having a much harder martensitic matrix structure. Irons of this type are considerably more wear resistant, stronger and tougher than unalloyed irons. Chilling refines the grain and further improves the mechanical properties of the alloy white irons. In some of these irons, up to 1% molybdenum is used to improve wear resistance.

Other martensitic irons are produced by employing high chromium or high molybdenum additions (see table). Chromium alloys containing from 10 to 30% chromium and as much as 4% molybdenum, and molybdenum alloys containing up to 12% molybdenum, show superior resistance to heat, abrasion and corrosion. These alloys are also generally tougher and stronger than the unalloyed grades.

PROPERTIES OF WHITE AND CHILLED IRONS

Type ➤	Unalloyed Chilled	Unalloyed White	Ni-Hard	High Chromium	Molybdenum
COMPOSITION, %	C 3.0-3.6 Si 0.5-1.6 Mn 0.25-0.70	C 2.8-3.6 Si 0.5-1.3 Mn 0.4-0.9	C 2.8-3.6 Si 0.4-0.7 Mn 0.2-0.7 Ni 2.50-4.75 Cr 1.2-3.5	C 1.3-3.5 Si 0.5-2.5 Mn 0.3-1.0 Ni 0.5 Cr 10-35 Cu 0.3 Mo 0-3	C 1.7-3.7 Si 0.3-2.6 Mn 0.2-1.5 Ni 0.5 Cr 0-6 Cu 0.1-5 Mo 0.3-12
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.274-0.280	0.274-0.281	0.275-0.280	0.264-0.280	0.275-0.285
Coef of Ther Exp, per °F	5.1-5.3 x 10^{-6}	5.0-5.3 x 10^{-6}	4.5-5.0 x 10^{-6}	5.2-5.5 x 10^{-6}	—
Elec Res, microhm-cm	5.0-5.3	5.0	80	—	—
MECHANICAL PROPERTIES					
Tensile Strength, 1000 psi	20-40	20-50	40-70	23-90	25-60
Hardness (Brinell)	350-575	300-575	525-600	250-700	350-700
Impact Str, ft-lb[a]	3.5-8	3.5-10	20-55	10-35	10-25
Transverse Test, lb[b]	2000-2800	2200-3000	4000-7000	2000-3500	1400-3200
Deflection, in[b]	0.03-0.12	0.03-0.15	0.08-0.12	0.06-0.15	0.05-0.15

[a]1.2-in. dia unnotched bar broken on 6-in. supports. (Gray iron ranges from 25 to 35 ft-lb.)
[b]Standard 1.2-in. dia bar loaded in center of 18-in. span.

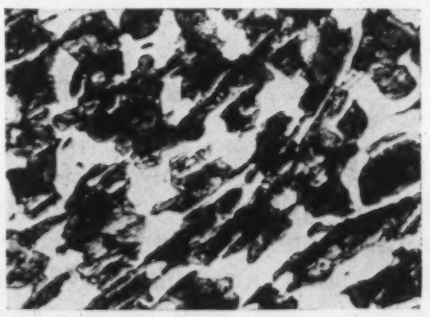
Applications

Unalloyed white iron — Unalloyed white iron, both chill and sand cast, is used primarily for applications requiring wear and

Effect of Structure

The manner in which carbon occurs in a cast iron has a profound effect on the properties. In ordinary gray iron most of the carbon is present as platelets of graphite, distributed at random throughout the matrix. By changing the chemical composition or the cooling rate, most of the carbon is retained as carbide. Accordingly, little graphite is formed and the result is white iron having a structure of massive carbides in a pearlitic matrix.

The properties of white iron are quite different from those of gray iron. For example, white iron is harder and has a higher compressive strength than gray iron but has lower impact resistance and is more difficult to machine and grind.



Pearlitic matrix

Martensitic matrix

Alloy additions alter the properties of white iron by changing the microstructure. The composition of the carbides becomes more complex, and the matrix structure changes from coarse pearlite to the lower temperature transition products of bainite or martensite.

Because of the large variations in alloy combinations, there are a number of alloy white irons in use. Rapidly cooled highly alloyed grades usually have a martensitic structure, whereas the more slowly cooled types have a predominantly bainitic matrix.

Properties of alloy white irons depend on the alloy combination and quantity, but considerable changes in strength, hardness, impact resistance, corrosion resistance and heat resistance are possible.

abrasion resistance without high strength and impact resistance. White iron castings are also successfully employed for applications at elevated temperatures up to 1200 F because they do not soften as drastically at these temperatures as hardened carbon and low alloy steels.

Although completely white cast irons are somewhat limited in application, because of their lack of impact resistance and machinability, they are used for equipment handling abrasive materials, such as liners in ore and cement mills, grinding balls, chutes and conveying equipment, ceramic dies, side plates, and impellers. Chilled iron with a soft interior, on the other hand, is widely used for dies, car and crane wheels, pulverizer and muller rolls, conveyor rollers and other materials handling equipment, since the unchilled surfaces of the casting can be readily machined to fit other parts.

Low alloy irons—Applications of these low alloy irons include grinding balls, blades for shot blasting and shot peening, rolling mill guides, mold boards for plows, and mine car wheels.

Martensitic irons—Nickel-chromium alloys of the Ni-Hard type are produced under a number of trade names. They are widely used for grinding balls and liners in grinding cement, ores and minerals, and for wearing parts in the pulverizing, pumping, mixing and conveying of abrasive materials such as feed grinding rings.

Martensitic white irons with high chromium and high molybdenum contents are employed in applications requiring resistance to severe wear and abrasion. They are also used for heat and corrosion resistance. Applications include valve seat inserts, slurry pump parts, grinding balls, liners, shot blast nozzles, jaw crusher plates and rolls.

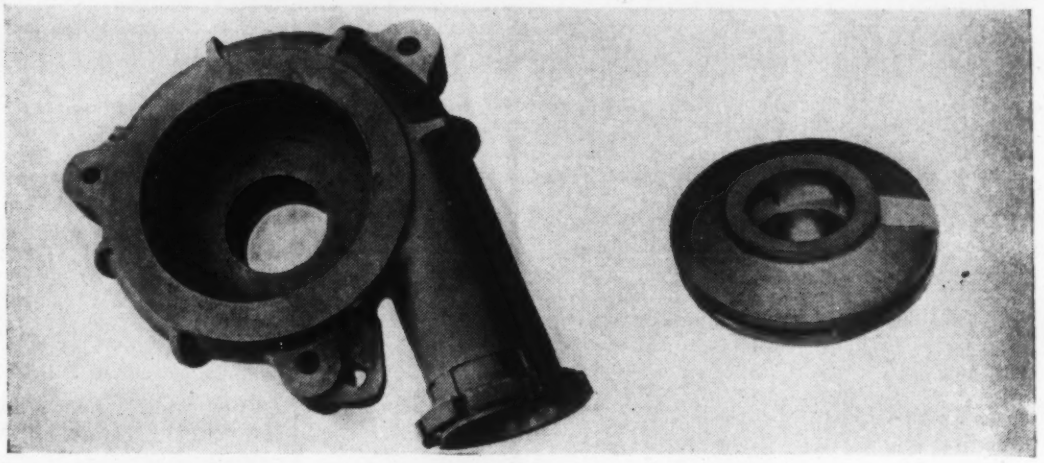
References

Alloy Cast Iron, 3rd edition, published by American Foundrymen's Society, 1944.

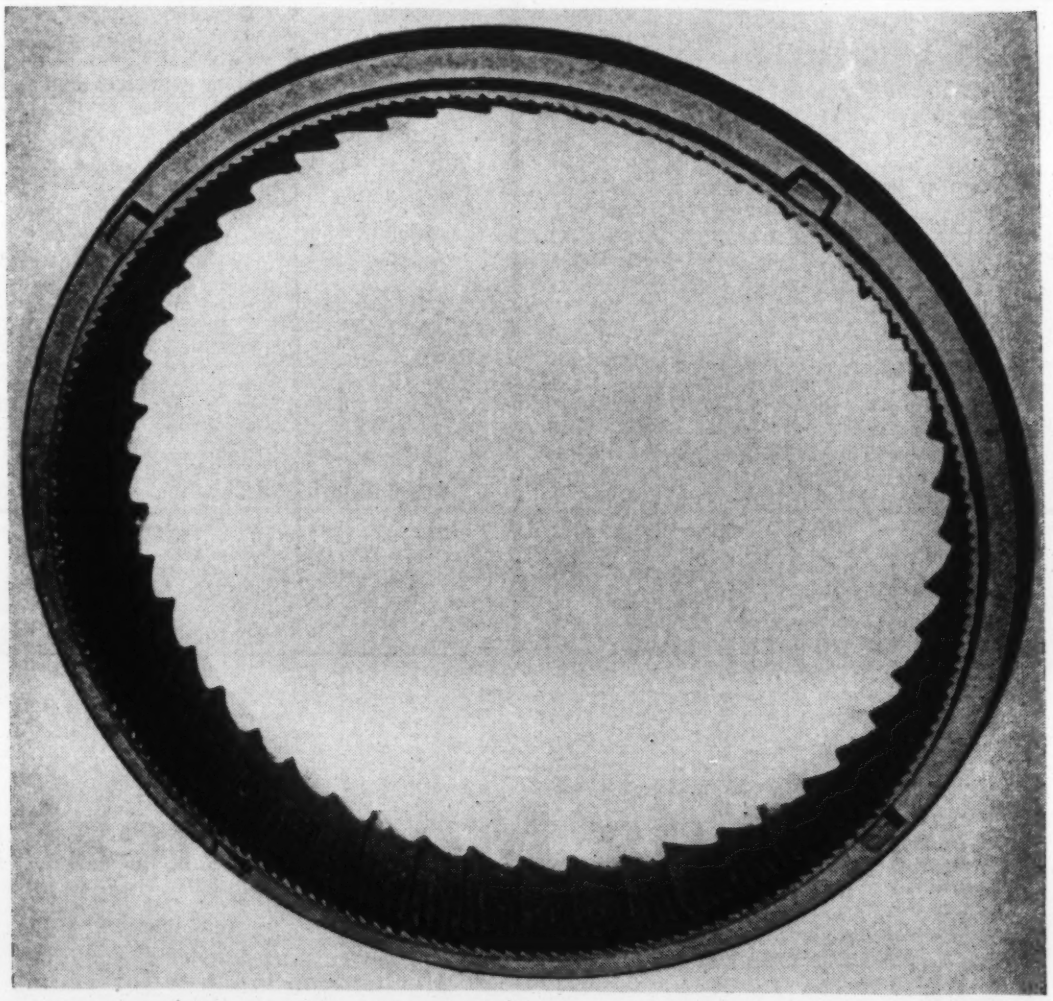
Cast Metals Handbook, published by American Foundrymen's Society, 1944, pp 540-556.

Metals Handbook, 1948 edition, published by American Society for Metals, pp 505-519.

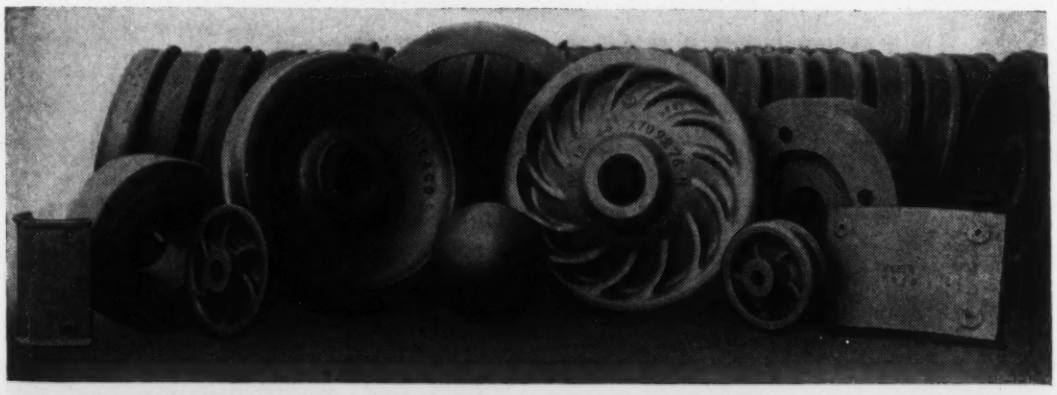
White iron castings are used for . . .



Impeller and pump housing—*high chromium white iron.*



Ring for poultry feed grinder—*high nickel-chromium white iron (Ni-Hard).*



Wheels, grinding balls and plates—*chilled white iron.*

This table is the first step in . . .

SURFACES OBTAINABLE BY MECHANICAL FINISHING

Type of surface . . .	. . . and how it is obtained		
	Method	Advantages	Limitations
Smooth Bright	Buffing	Brightest mechanical finish obtainable	Multi-step process. Comparatively expensive and time-consuming for finishing of small parts
	Burnishing	Low cost. Adaptable to finishing of small parts in large quantities	Surface is not as bright as buffed finish. Care required not to destroy surface dimensions and contours. Difficult to burnish large parts
Satin Semibright	Wire brushing; "greaseless polishing"; wheel or belt polishing	Low cost. Surfaces have softer, smoother sheen with lower reflectivity than buffed finish	In general, these methods produce about the same type of finish. Choice of any one depends on individual preference and equipment availability
	Rubbing with steel wool	Can be used to finish irregularly shaped parts	Care required to impart uniform finish and prevent directional patterns
Textured Semibright	Hammering	Attractive, decorative finish similar to wrought silver	Comparatively high cost. Production of complicated surfaces does not lend itself to high production rates
	Embossing	Wide variety of decorative effects. Obscures surface defects and withstands careless handling	Applicable to flat surfaces only
Textured Matte	Sandblasting	Special decorative effects	Has tendency to collect and retain dirt unless protected by clear lacquer or varnish coating
	Embossing	See above	See above

Selecting Mechanical Finishes for Aluminum

by R. V. Vanden Berg,
Aluminum Co. of America

■ Mechanical finishes for aluminum are important from both a decorative and functional standpoint. A number of finishes are available that are designed to remove scratches, pits or other surface defects and provide a smooth surface with a bright or satin appearance. Textured finishes, produced by blasting, hammering or embossing, have also gained wide acceptance in recent years because of their decorative appeal. Like the smooth finishes, textured finishes can be lacquered, anodized or chemically treated.

Satin finishes

Satin finishing is an established method for treating aluminum hardware items such as knobs, hinges, rosettes and drawer pulls. Satin finishes can be applied by fine wire brushing, or by using an abrasive "greaseless" compound in conjunction with a conventional buffing head, tampico brush wheel or brush-backed sander head. These methods produce about the same type finish, and use of any particular one depends on individual preference.

The fineness of a wire brushed

finish is, of course, determined by the size of wires in the brush. Excellent satin finishes can be obtained on aluminum provided the surfaces are free from grease or oil and low pressures are used. A commonly used wire brushing combination consists of 0.015-in. wire mounted on a 10-in. wheel revolving at about 600 rpm.

Stainless steel wires are recommended, since other metals such as brass or steel may become embedded in the aluminum surface and produce discoloration or corrosion. Particles that become embedded in the surface can be removed by treatment in nitric acid.

The greaseless compound processes are essentially wet processes. Water is required to soften the binder in the abrasive compound so that it will adhere to the wheel surface. The finish produced by these processes is very attractive and has a smooth sheen with lower reflectivity than a buffed surface.

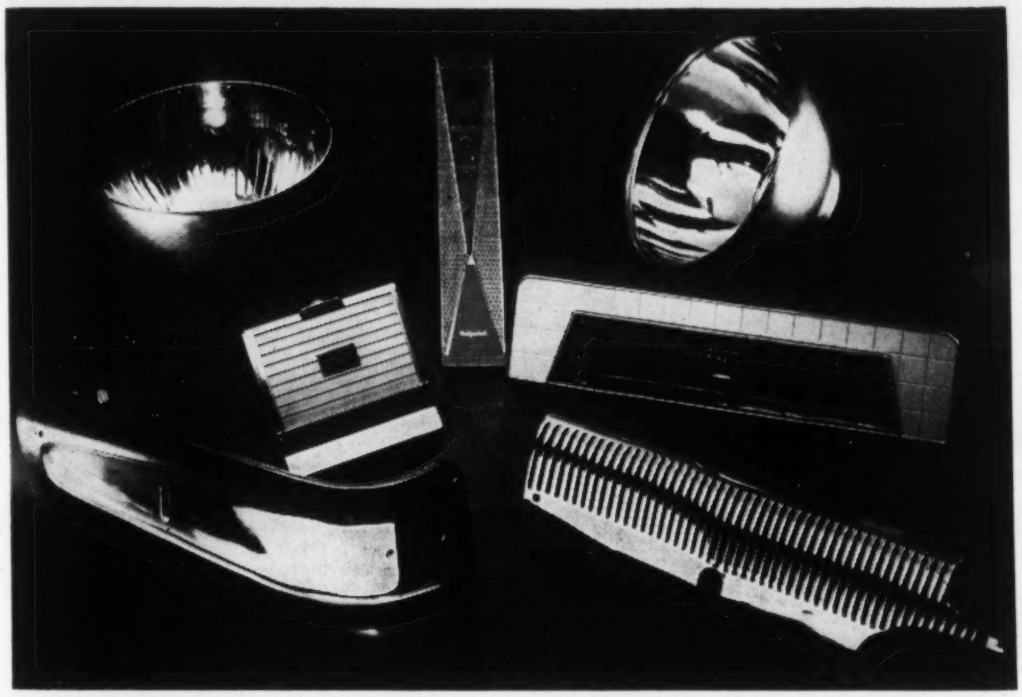
Satin finishes can also be produced by wheel or belt polishing. These methods produce a smoother sheen than wire brushing or finishing with an abrasive compound because of the more irregular, finer scratches on the surface.

Satin finishes with an attractive sheen are also obtainable by hand rubbing with steel wool. Texture of the finish depends on the fineness of the steel wool. Soap and water, or oil, can be used as a lubricant. Care is required to impart a uniform texture and prevent directional patterns. Because of the time required, the process is relatively expensive and is limited to architectural components such as handrails, moldings or other irregularly shaped parts.

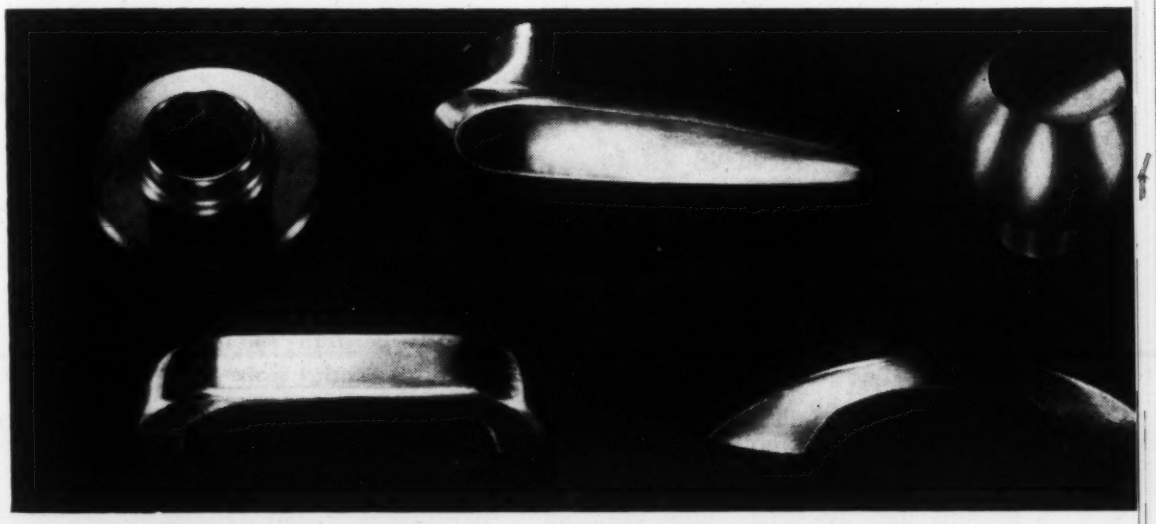
Polished finishes

Polishing is used for both preliminary and final finishing; i.e., it is used to remove the coarse texture imparted by grinding and, in subsequent finishing, to impart an attractive satiny sheen. Texture of the finish depends upon the type and fineness of the abrasive used. Wheels are usually faced with Turkish emery, an abrasive containing about 80%

WHAT THEY LOOK LIKE

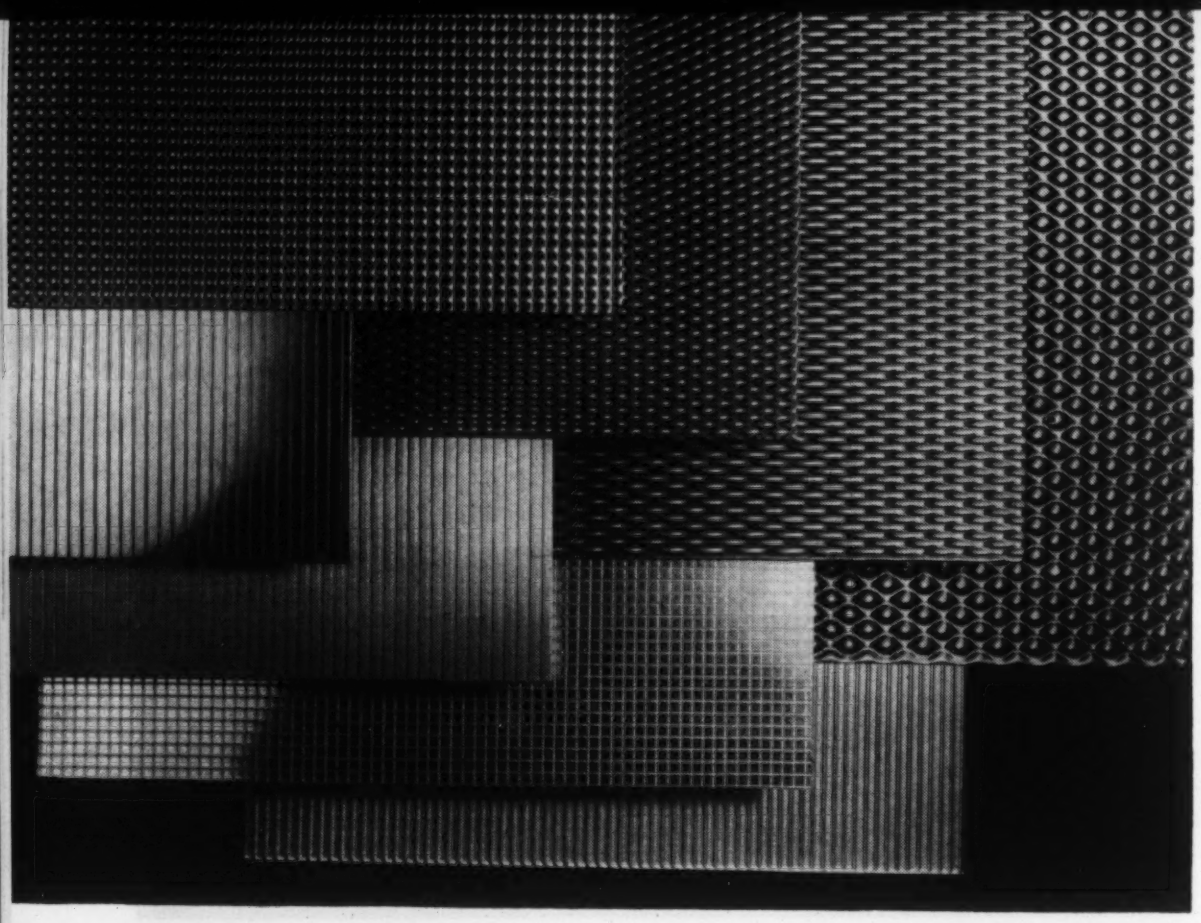


Buffed Finish



Satin Finish

Hammered Finish



Patterned Finish

aluminum oxide, which is held to the surface by animal glue. Abrasive grains vary from 40 to 320 emery.

Polishing wheels are similar to grinding wheels and are generally constructed of felt or stitched cloth buffs glued together to the desired face width. Faces of the wheels can be contoured to the surface being polished. Sharp contours in difficult to reach areas should be avoided, however, as the specially designed wheels and contact heads required generally result in higher costs and lower production rates.

In general, several wheels are used for polishing, beginning with the coarsest and ending with the finest. Lubrication with tallow or a heavy grease is usually required with the finer abrasives to prevent loading of the wheel face and overheating. These wheels are commonly referred to as "oilwheels" and the process as "oiling." To prevent overheating of the metal surface and prolong wheel life, wheels are not usually operated at surface speeds over 5000 to 6000 fpm.

Belts faced with either aluminum oxide or silicon carbide abrasive and a lubricant are becoming increasingly popular for finishing aluminum. Because of the large contact area and reduced danger of overheating, contact wheels are used for high rates of metal removal. Contoured faces are also available for polishing complicated shapes. The versatility of belt grinding has been demonstrated in the production of tapered aluminum sheets, 7 ft wide by 8 ft long, for aircraft. Large quantities of water soluble lubricants are passed over the surface during polishing. The process has resulted in considerable savings over conventional skin milling.

Buffed finishes

Buffing is a refinement of polishing and satin finishing. The surface produced is smooth and lustrous (see photo) and is obtained by a combined cutting and flowing of the metal. Temperatures as high as the melting point of aluminum may be reached at microscopic contact points, and over-all temperatures of more than 500 F are frequently encountered. These high temperatures are responsible for the flowing of the surface film (Beilby layer). Although surfaces have a smooth, mirror-like appearance, they are not truly optically flat.

Buffing is generally divided into three operations consisting of cutting, cutting and color buffing, and color buffing. Cutting, as its name implies, is primarily intended to remove surface imperfections. Surface speeds of 7000 to 8000 fpm are usually employed. Faster cutting is obtained at the higher speeds since the buff tends to compact and become harder. Too high speeds, however, should be avoided to prevent overheating, buff burning and surface pitting.

Cutting and color buffing is a combination operation designed not only to remove surface imperfections but to burnish out some of the fine scratches produced during preliminary cutting. The buffs and abrasive compounds used are a compromise designed to produce some of the characteristics of preliminary cutting and final color buffing. Softer buffs are used than in cutting, and the surface is reasonably smooth with fair luster.

Color buffing is usually the last step in buffing and is intended to burnish out the fine scratches produced during preliminary buffing. Color buffing compounds are composed of the finest abrasive powders, such as white silica or rouge, incorporated in suitable binders. These compounds produce a surface with high gloss and bright finish. Color buff wheel disks are constructed of open weave (low thread count) fabrics, stitched only at the spindle hole for extreme softness and flexibility at high speeds.

Buffs vary considerably in design and structure, and are made in both hard and soft types. In general, the hard buffs produce faster cutting rates and are more inclined to overheat. Hard buffs are made from muslin disks with a high thread count and close spiral stitching. Folded buff and bias buff designs are also quite popular for aluminum and are used where fast cutting combined with greater flexibility is required. These two designs have good ventilation and tend to minimize buffing streaks, an important factor in automatic tandem equipment.

Soft buffs are made from disks with low thread counts and wide

spiral stitching. These buffs flow or shape the surface and produce little cutting or removal of surface imperfections. Spacers are sometimes used between buffing sections to obtain more flexibility.

Selection of the proper abrasive compound is extremely important in obtaining a desired finish. Compounds for aluminum generally consist of an abrasive of tripoli powder incorporated in a suitable binder. These compounds are commonly supplied in the form of solid bars; however, liquid buffing compounds are also popular. Since the liquid compounds can be applied by spraying, they are particularly effective in high production automatic buffing equipment.

The quality of a buffed surface depends a great deal upon the skill of the operator, especially if the surface is to be subsequently brightened and anodized. Excessive pressure causes localized hot spots and nonuniform pressure produces irregularities which become readily apparent after anodizing. Particular care is required with the softer, higher purity alloys. High pressures have a tendency to produce "drags" or small elongated pits in the surface. The harder alloys, such as 3003, 5005, 5050 and 5357, generally respond more satisfactorily to buffing.

Because of their smooth as cast surface, little polishing and buffing is required to produce a lustrous finish on die castings. Polishing is generally confined to surface projections caused by gates, ejector pins or parting lines. Excessive polishing should be avoided as exposure of porous areas complicates subsequent electroplating and anodizing, particularly if the finish is to be colored.

Because of their greater porosity, sand and permanent mold castings are generally more difficult to polish and buff than die castings. Careful polishing is required before buffing to prevent excessive pitting at the pores. Because of their tendency to entrap buffing compounds, surface pores prevent cleaning and hinder electroplating and anodizing operations.

Electrobrightening or chemical brightening are frequently used to obtain a bright and smooth finish on surfaces that are to be anodized. These processes have a "micro-smoothing" effect and remove the thin surface film contaminated with buffing compound.

Buffed surfaces are frequently given a slight etch in a caustic soda solution in applications where surface brightness is undesirable. This technique is referred to as toning, and the resulting surface has a smooth matte finish.

Burnished finishes

Barrel burnishing is a comparatively simple, low cost method of obtaining smooth and bright surfaces on aluminum. The method is particularly suited to high production finishing of small parts.

Burnishing is accomplished with two types of media, depending on the finish required. Granite chips or a similar abrasive mixed with water and soap lubricant are used primarily to remove surface metal and obtain a smooth surface. This type of treatment is not recommended for screw machine parts containing threads or for similar close tolerance surfaces.

The second, and most widely used, burnishing method utilizes polished steel balls, cones or other appropriate shapes with soap and water or oil. Ball burnishing produces a bright finish and, if properly controlled, will not destroy threads or other surface contours. It will, however, effectively remove burrs and similar surface irregularities on machined surfaces. Parts with sharp corners or threads must be burnished at slower speeds, and it is frequently necessary to sacrifice some quality of finish if absolute dimensions are required.

Ball burnishing produces a smooth surface by peening down ridges and filling up hollows. Surface defects that are too small to permit the entrance of burnishing media, yet are too large to be filled by adjacent metal, will usually show up after burnishing. Hard-to-reach recesses in complex shaped parts also present difficulties. In many cases the burnishing media cannot act on certain

Meat slicer housing *has anodic coating over satin finish to increase resistance to staining and abrasion.*

areas because of their inaccessibility. Also, large holes and pockets have a tendency to trap burnishing media and prevent effective action.

In general, a brighter finish after burnishing will be obtained on areas that have been machined and that are comparatively free of oxide. To achieve uniform brightness it is usually necessary to remove the oxide film from unmachined areas by etching in a 3% caustic soda solution and dipping in a nitric acid solution.

A greater shot-to-work ratio is generally required for larger parts. Small parts tend to be supported by the burnishing media and are more liable to keep separated than larger parts. Also, there is more danger of surface damage when large heavy parts or parts with flat surfaces come into contact.

Recently barrels have been designed that incorporate fixtures to hold large parts in a fixed position. Since the parts are contacted only by the abrasive mixture and not by each other, the possibility of breakage and surface damage is minimized.

Also, very small, fragile parts can now be ball burnished by a process known as submerged barrel burnishing. This process utilizes a barrel-like container which is completely submerged and rotated in the burnishing mixture. The cushioning effect of the water reduces the impact of parts on each other.

Brightness of burnished surfaces depends largely upon the time of treatment and the relative movement and pressure of the media over the surface. Thus, uniform brightness depends upon the shape and distribution of metal in the part. Other things being equal, less time is required to obtain uniform brightness on symmetrical parts. For this reason, a sphere will attain a more uniform finish than a bolt.

It is important that a neutral soap be used for burnishing aluminum. Alkaline soaps stain aluminum and also react with the metal to evolve hydrogen gas. This gas accumulates under pressure and can be a serious fire hazard when the barrel is opened.

A variation of the burnishing process known as sand burnishing is sometimes used to produce an inexpensive matte or satin appearance on large flat areas. Parts are placed in a tray containing sand and water and given a reciprocating motion to abrade the surface.

Blasted finishes

The term sandblasting is generally used to describe the application of any abrasive material to a surface. Although sandblasting is usually used for cleaning, it can also be used to produce a variety of matte and decorative finishes.

The texture of the surface is determined by size and type of abrasive, air pressure, and movement and angle of the nozzle. The finer the abrasive, the smoother the finish. A comparatively rough finish is obtained with washed silica sand. The smoothest finish is obtained by dust blasting with fine abrasive and by vapor honing. The vapor honing process utilizes a slurry made up of an extremely fine abrasive and water which is applied by air pressure.

(Because of its severe cutting action, steel grit is not generally used for aluminum. Steel shot, however, is used to produce a peened and burnished surface which is not as rough as a sand blasted finish. Shot blasting is primarily used for its functional, rather than its decorative effect, and is extensively used to improve fatigue characteristics.)

Nozzle movement and position are particularly important during sandblasting to produce a uniform surface appearance, particularly on wide flat surfaces. To prevent the formation of surface patterns, techniques have been adopted utilizing a fixed nozzle and conveyorized movement of parts at a fixed rate. Selection of proper blasting techniques is also necessary to prevent distortion of thin sections of metal.

Since the surface produced by even the finest abrasive is rough, fingerprints readily, and collects and retains dirt, some sort of protective treatment is necessary to retain the appearance of the original surface. Clear gloss lacquers are often used for this purpose. These lacquers have a tendency to darken the surface somewhat.

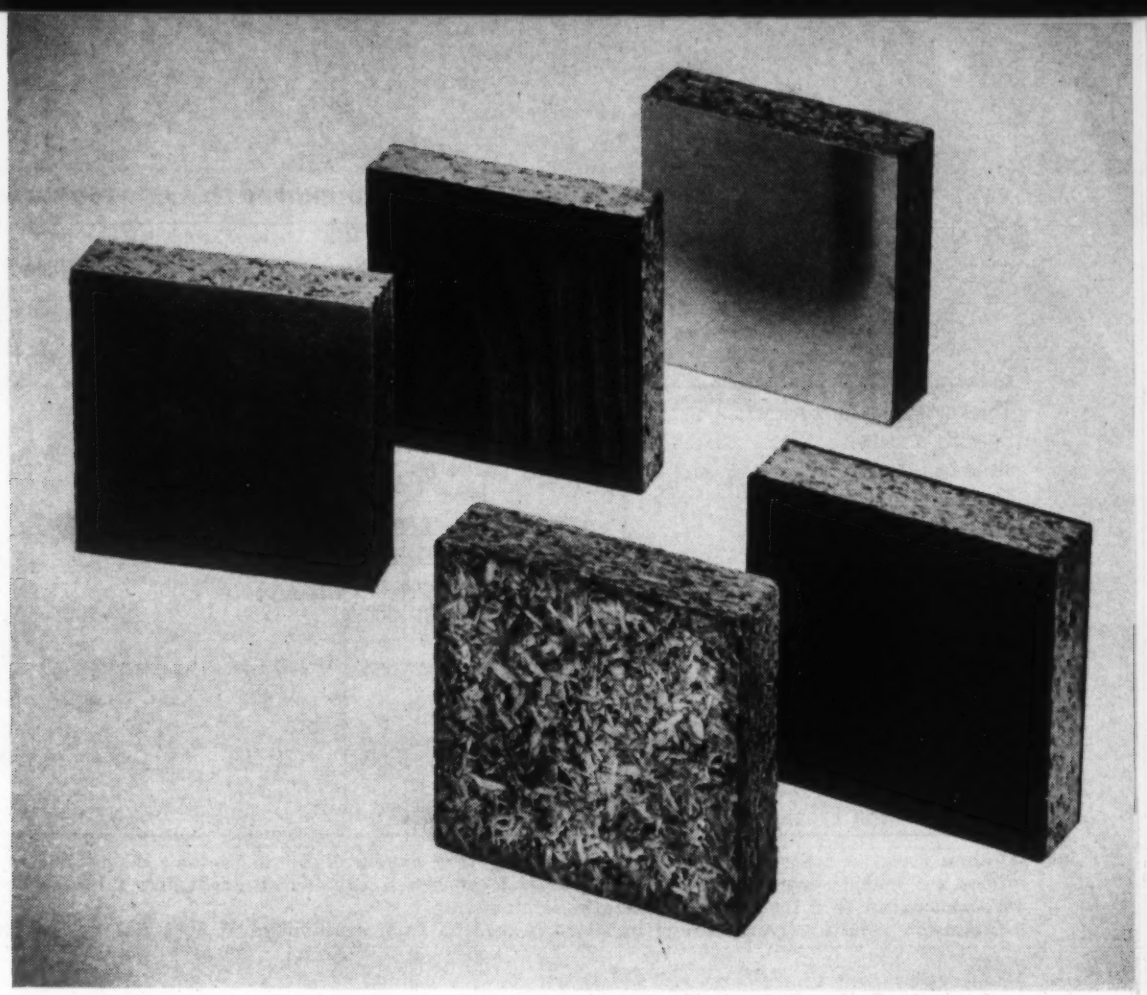
Anodizing provides an excellent protective coating for sandblasted surfaces. It is particularly effective on castings, and is used to produce an attractive decorative finish on plaques. In this application, known as highlighting, the background is sand blasted after selected portions are either polished or buffed. The contrast is accentuated after anodizing since the sandblasted background is a dark gray. If this extreme contrast is not desirable, the sandblasted surface may be etched with caustic soda or nitric-hydrofluoric acid solution prior to anodizing to remove some of the surface aluminum in which the discoloring abrasive is embedded. This process is known as bleaching and produces surfaces with a matte appearance.

Hammered and patterned finishes

Hand hammering provides one of the simplest mechanical finishes for aluminum. The finish closely resembles hand wrought silver and is principally used for novelties and giftware. It is particularly advantageous in that it tends to obscure minor scratches and other defects.

An effect suggestive of wrought iron can be obtained by heating aluminum parts in a smoky coal fire until the surface is covered with a fine layer of black soot, then hammering until part of the soot becomes embedded in the surface. The raised portions are often highlighted by rubbing with emery or steel wool.

Effects quite similar to hammering can be obtained by passing sheet or foil between engraved rolls, or by embossing parts after they have been fabricated. These patterned surfaces are primarily used for their decorative value on doors, wall panels and automobile trim and in some functional applications as nonskid surfaces. Patterns are available in an unlimited number of designs (see photo).



National Starch Products, Inc.

Sandwich structures *make ideal use of composition board. Board (shown in front) can be faced with wood veneer, plastics or metals.*

Versatile, Low Cost Wood Composition Boards

by Malcolm W. Riley,
Associate Editor,
Materials in Design Engineering

■ Wood composition board is an engineered synthetic lumber made by compacting wood particles or fibers under heat and pressure, either with or without additional resin binders. Primary features of wood composition board are: 1) low cost, 2) rigidity, 3) absence of grain or knots that could check or mar the surface, 4) uniformity of strength in all directions parallel to the surface and 5) versatile decorative possibilities inherent in the make-up of the material.

Because engineering data on the materials are relatively new, many potential applications in the product design field have not been explored. Except for building and architectural applications, pri-

U. S. Plywood Corp.

Decorative possibilities *of particle board are shown by this expandable teacher's desk (designed by Daniel, Mann, Johnson & Mendenhall).*

GENERAL CLASSIFICATION AND PROPERTIES OF WOOD COMPOSITION BOARD[a]

Properties ↓ Class →	Hardboard (fibrous)			Particle Board		Softboard (insulation)		
	Untreated	Treated	Special Densified	Low Density[b]	High Density	Semirigid	Rigid	Intermediate Density
Thickness Generally Available, in.	1/10-5/16	1/10-5/16	¼-2	¼-¾ [c]	1/10-⅜	½-1-½	⅜-1[d]	3/16-½
Specific Gravity	0.88-1.04	0.95-1.15	1.35-1.45	0.40-0.80	0.80-1.05	0.02-0.15	0.15-0.40	0.40-0.80
Density, lb/cu ft	50-65	60-70	85-89	25-50	50-70	1.5-9	9-25	25-50
Thermal Conductivity, Btu/sq ft/hr/°F/in	0.80-1.40	1.50	1.85	0.40-0.80	—	0.24-0.27	0.27-0.40	0.40-0.80
Modulus of Rupture, psi	3000-7000	7500-10,000	10,000-12,500	400-4000	3000-7500	—	200-800	400-4000
Modulus of Elasticity in Bending, 1000 psi	400-800	800-1000	1250	300-700	400-1000	—	25-125	90-700
Tensile Strength, psi								
Parallel to Surface	1000-3000	4000-5500	7700	100-1350	300-2500	—	200-500	800-2000
Perpendicular to Surface	—	—	500	90-400	275-400	—	10-25	—
Compression Strength (parallel to surface), psi	1800-6000	4200-5300	26,500	—	3500-4000	—	—	500-3400
Water Absorption (24 hr), % by wt	3-18	3-13	0.3-1.2	5-50	15-40	—	—	—
Maximum Linear Expansion, %[e]	0.60	0.40	—	0.40[b]	0.85	—	0.50	1.30

[a]Values given in table are approximate since they vary among different products depending on materials and manufacturing processes used.
[b]Does not include extruded board. [c]The extrusion process is capable of producing thicker board.
[d]Specimens up to 3 in. thick are made by lamination.
[e]Expansion resulting from change in moisture content from equilibrium at 50% RH to equilibrium at 97% RH.

Three Major Types

Two production methods are used for producing composition board: platen press and extrusion. The large majority of wood composition board used today is of the platen press type, and this article is primarily concerned with this type.

In general, the many wood composition boards can be classified into three types, based primarily on the nature of the wood ingredient and on the nature of the bonding material. These three types are further subdivided primarily on the basis of density. The three major classifications are:

1. **Hardboard** is made by felting ligno-cellulosic wood *fibers* which have been formed by steam exploding or mechanical fiberizing techniques. The felted fibers are then consolidated under heat and pressure into a board in which the primary bond is a natural ligneous one. Binders may be added to improve the natural bond.

2. **Particle board** is made of *flakes, chips, splinters* or *particles* of wood, bonded with a synthetic resin or other binder. In general, use of any of the four forms of particles produces board with similar properties.

3. **Softboard** (insulation board) is made from wood *pulp* or *bagasse* (processed sugar cane) held together entirely by the felting properties of the fiber.

mary uses for composition board have been in furniture manufacture. Probably the largest use of the board in furniture has been as a core material, used in combination with a veneer of wood, plastics or metal. The suitability of composition board as a core material should stimulate its use in sandwich construction.

Composition board can be classified into three basic types, depending on the geometry of the wood ingredient and the nature of the bond. Each of the three types can be further classified by density, since density is one of the most significant properties of the boards and has a controlling influence over many other properties. In general, as density increases, mechanical strength increases. Thermal conductivity also increases, reducing the insulation value of the material. Density is not the only controlling factor, since altering the ratio of binder to wood for a given density will also alter physical properties.

Hardboards

Hardboards are formed by compacting the wood fibers under heat and pressure to form a strong homogeneous mass. The high pressures produce a hard surfaced material. The bonding of the fibers in the board results from chemical changes taking place in the composition of the wood, and the bond can be augmented with additional binders. Other chemicals may be added to provide resistance to moisture, fire, decay or vermin. Though hardboard, like natural wood, is subject to swelling on exposure to moisture, the amount of absorption and subsequent dimensional change can be controlled within certain limits.

Classified by density, hardboards include three types: untreated, treated and special densified. Untreated hardboard generally ranges in density from 50 to 65 lb per cu ft, has a modulus of rupture of 3000 to 7000 psi, and a modulus of elasticity in bending of 400,000 to 800,000 psi. Treated hardboard has a density ranging from 60 to 70 lb per cu ft, a modulus of rupture of 7500 to

10,000 psi, and modulus of elasticity in bending of 800,000 to 1 million psi.

Special densified hardboard, treated to increase density, strength and resistance to wear and moisture, has a density generally ranging from 85 to 89 lb per cu ft, a modulus of rupture of 10,000 to 12,500 psi, and modulus of elasticity in bending of over 1 million psi.

Hardboard is used as a construction material because of its high strength, uniform density, thickness and color, and its hard smooth surface. It can be bent to relatively small radii to meet specific design requirements. It has many of the same applications as thin plywood, and is used for furniture, transportation equipment, specialty items and industrial applications. Densified hardboard is used in die-making, and for jigs and fixtures, mock-ups and templates. Some types of densified hardboards have good dielectric properties and can be used as insulated control panels and as bases for certain electrical power apparatus. Unfortunately, few data on dielectric properties are available.

Particle boards

A great many types of wood composition board can be classified as particle board. Particle board consists of discrete particles of wood in the form of flakes, chips, splinters or particles, compacted under pressure and heat and bonded with a material such as urea formaldehyde.

Each materials supplier has his own philosophy on the type of particle to use and the particular production techniques required to provide the best combination of properties in a board. Because of the number of such producers, it would be impossible here to detail the individual types available. However, the general properties described here are typical; further details should be obtained from the various producers.

In general, particle boards are similar to hardboards in that, 1) they have hard surfaces, 2) other chemicals can be added to improve resistance to moisture, fire, decay and vermin, and 3) the amount of moisture absorption and subsequent dimensional change can be controlled within certain limits.

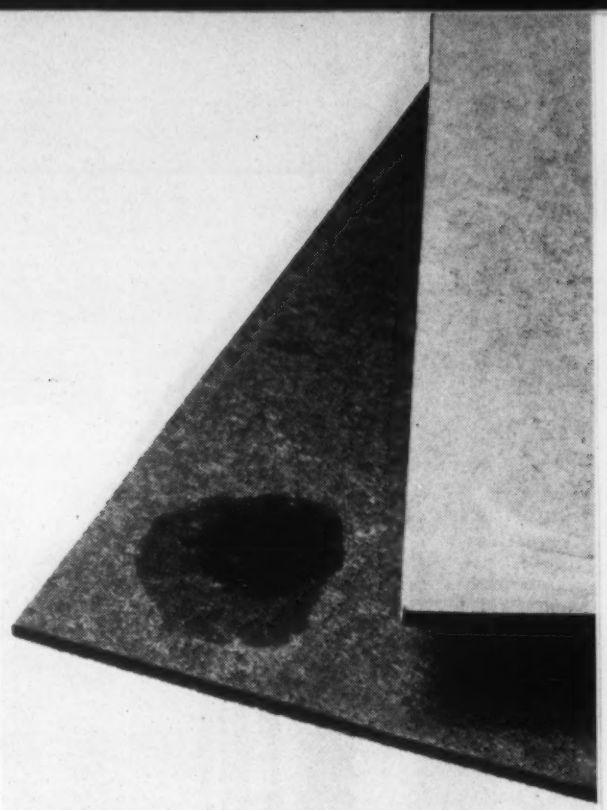
Particle boards can be classified into low and high density types. Low density board has a density ranging from 25 to 50 lb per cu ft, a modulus of rupture of 400 to 4000 psi, and a modulus of elasticity in bending of 300,000 to 700,000 psi. High density particle board ranges in density from 50 to 70 lb per cu ft, in modulus of rupture from 3000 to 7500 psi, and in modulus of elasticity in bending from 400,000 to 1 million psi. Most particle board producers seem to have arrived at about a 40 lb per cu ft density as the optimum.

With the exception of architectural applications, probably the largest volume of particle board is used as core stock in furniture manufacture. Particle board can also be used for many of the applications for which hardboard is used, depending on the specific property requirements. Decorative effects that can be achieved with particle board are varied and numerous. By altering shape and size of particles or wood-binder ratio, many different surface appearances can be obtained. Another interesting possibility, according to wood technologists, is the molding of particle board compositions into a variety of shapes.

Softboards

The method used for producing softboards is similar to that used for producing thick papers, i. e., mechanically felting component wood or bagasse fibers into a mat. The matted material is then rolled or screen pressed to consolidate it and squeeze out excess moisture before drying. No binder is added, and the resulting product is porous throughout its thickness. The majority of the softboards produced today are made of bagasse (processed sugar cane).

Softboard can be classified as semirigid, rigid and intermediate density. All three types are used primarily as thermal and acoustical insulation. The semirigid types, with densities ranging from 1.5 to 9 lb per cu ft, have thermal conductivity values of 0.24 to 0.27 Btu/sq ft/hr/°F/in. The rigid types, with densities of 9 to 25 lb per cu ft, have thermal conductivity values ranging from 0.27 to 0.40 Btu/sq ft/hr/°F/in.

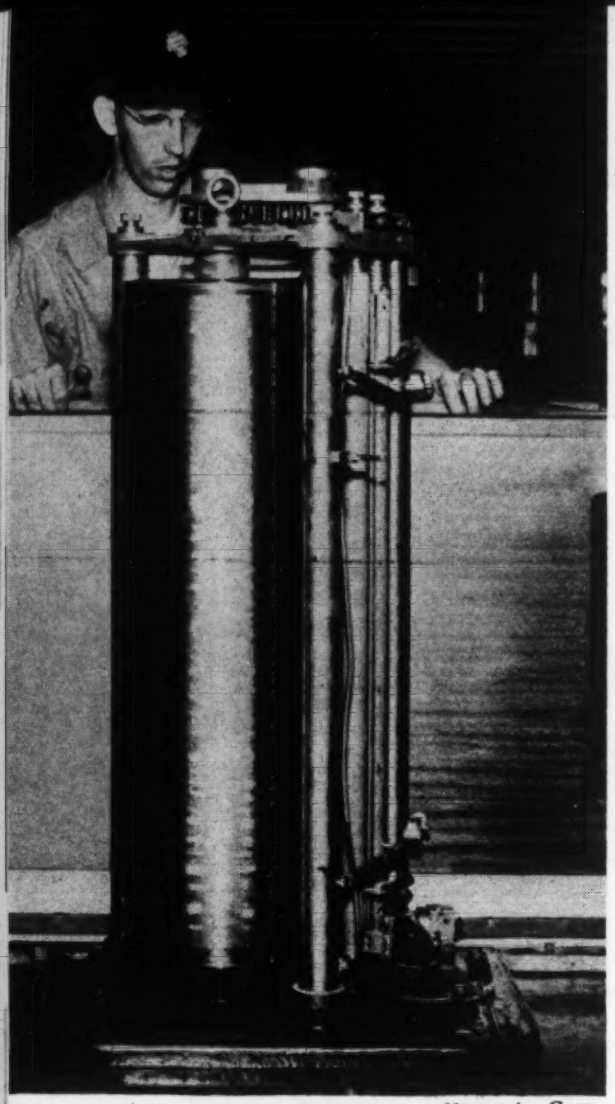


Forest Fiber Products Co.

Treated hardboard, *at right, permits easy cleaning and resists staining by greases and oils better than untreated hardboard (left).*

Masonite Corp.

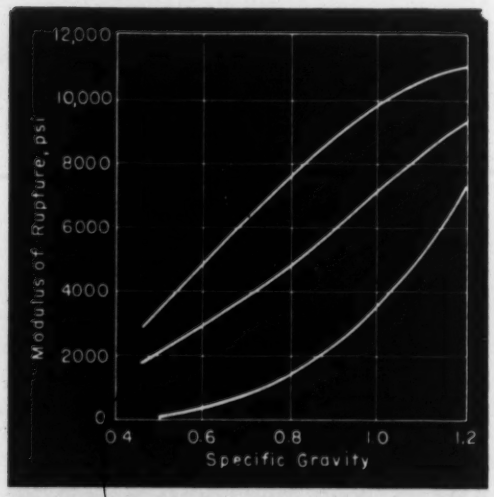
Furniture *is one of the major applications for composition board at present. This steel frame storage cabinet made by Herman Miller Furniture Co. uses hardboard.*



Masonite Corp.

Printed surfaces *can be applied to composition board to provide a variety of decorative or protective finishes. Here a woodgrain pattern is applied over a ground coat by offset gravure. It will be protected by a clear top coat.*

The intermediate density types, with densities ranging from 25 to 50 lb per cu ft, have thermal conductivity values ranging from 0.40 to 0.80 Btu/sq ft/hr/°F/in. These types also have relatively good mechanical strength. Modulus of rupture values ranges from 400 to 4000 psi, and moduli of elasticity in bending range from 90,000 to 700,000 psi.



Strength-density *relationship of particle board is shown here qualitatively by typical curves for boards made of particles of various shapes and various woods.* (McGee)

Semirigid type softboard has the lowest density and lowest thermal conductivity values of all composition boards. It is used for insulation in bus and truck bodies, passenger cars, railroad cars, refrigerators and other applications where loose-filled insulating material would be undesirable because of vibration. Rigid and intermediate density softboards are used primarily in building construction as thermal and acoustical insulation. Though the rigid type has better insulating properties, the intermediate density material is more scuff and mar resistant.

Properties

In general, solid lumber is superior to most composition board in such properties as strength in bending, tensile strength, screw holding ability and machinability. It also has lower density than most of the structural composition boards. Composition board, on the other hand, generally is harder, offers more control over dimensional stability, has lower thermal conductivity and has fewer defects throughout the piece.

Density—Density is one of the most important properties because of the influence it has on other physical properties of the board. As density increases, bending strength increases (see accompanying curves). Density is also related to workability, ease of veneering, screw and nail holding ability, hardness and dimensional stability. Though screw holding ability increases with increasing density, dimensional stability decreases. Thus, in many applications where dimensional stability is a critical requirement lower densities can be specified, and if screw holding ability is not sufficient for the particular application, other methods of joining can be used.

In many cases, though higher densities will provide higher strengths, weight can be the critical factor. In furniture manufacture, for example, according to *McGee*, the consensus of experts in the furniture field is that, for maximum saleability, furniture should be made of composition board having a density between 34 and 50 lb per cu ft.

Dimensional stability—Control and prediction of dimensional stability are more easily accomplished in composition board than in any but the highest quality solid wood. The natural variations in wood caused by growth rings, knots, lightning scars and pest damage cause unpredictable changes. On the other hand, some shortcomings in structural uniformity of composition board can result from presently used production methods. The two largest faults encountered are settlement of fines and unevenness of mat formation prior to application of heat and pressure.

The two major types of dimensional change occurring in composition board are springback and swelling due to moisture. Moisture is the primary cause of dimensional changes, since change in moisture content of wood substances causes expansion and contraction of the wood cells. The typical degree of dimensional change caused by moisture pick-up in the various types of composition boards is shown in the accompanying table of properties. Some control over moisture absorption of composition board is accomplished by using additives that inhibit moisture pick-up.

Springback is the dimensional change resulting from release of the internal stresses inherent in the compressed composition board mass. The most likely trigger for such releases is increased moisture content, which tends to permit the individual particles to return to their normal uncompressed state. One control over springback that can be exercised by the materials producer consists of subjecting the boards to controlled humidity cycling. Other factors affecting springback are the amount of resin binder and the density of the board. In-

creased resin content usually results in less springback. Though there is no direct correlation between density and amount of springback, heavier boards usually tend to develop a higher degree of springback.

Strength—Ranges of mechanical strengths obtainable with various types of composition boards are shown in the accompanying table of properties. According to some authorities, mechanical strength characteristics are in many cases overvalued in designing with composition board. In furniture use, for example, *Caughey* says that a modulus of rupture of only 1500 psi is sufficient for quality panels that are to be veneered. Recommended tensile strengths of boards to be used for furniture are slightly more than 700 psi. Other strength values that should be considered are shear strength, toughness, hardness, compressive strength and modulus of elasticity.

The use of composition board as a core material in sandwich structures provides some startling mechanical properties. Veneering and crossbanding usually increase bending strength of board about threefold. According to reports from one company, use of only kraft paper facings on each side of a particle board with a modulus of rupture of 1500 psi and a modulus of elasticity in bending of 250,000 psi provides a sandwich structure with a modulus of rupture of 3800 psi and a modulus of elasticity of 360,000 psi.

Fabrication and design

Since wood composition boards are wood products, they can be fabricated by standard woodworking techniques. Because of the presence of synthetic resin binders in many types, producers generally recommend use of carbide-tipped cutting tools for optimum results.

Surfacing — Many commercial composition boards are available with a variety of veneers or surfaces (see discussion on finishing below). In specifying a composition board to which a veneer is to be applied, greater irregularities of surface can probably be tolerated in boards of lower density than in boards of higher density. According to *McGee,* when pressure is applied during veneering, surface chips of the less dense boards flatten out more than those of denser boards, reducing the number of gaps and ridges that contribute to poor glue bonds.

Surface quality of commercial composition boards can be improved to some extent by retaining a certain amount of fines in the composition mix; these fines help fill gaps in the board surfaces. In such cases, however, there is some sacrifice in strength and an increase in density, since the fines readily absorb resin binder.

Bending—Of the various types of composition boards, hardboards lend themselves best to forming by bending. They can be bent by "hot moist," "cold moist" and "cold dry" techniques. Though the various types of hardboards have specific bending properties, in general, ⅛-in. thick pieces can be bent to minimum radii of about 2 to 3 in. by hot moist bending techniques, 6 to 7 in. by cold moist bending techniques and 9 to 12 in. by cold dry bending techniques. Thicker boards require larger radii.

Particle boards of about ⅜-in. thickness can be bent to minimum radii of about 12 to 14 in. by damp bending techniques. In thicker sections, plywood techniques must be used; in some cases minimum radii can be as little as 8 in.

Joining—Composition board can be joined or fastened by almost any of the techniques commonly used for joining wood, though the characteristics of the joint will depend on the type of board used.

It can be nailed, screwed, bolted, glued or fastened mechanically by such devices as dowels, etc. Nail and screw holding abilities of composition boards are difficult to evaluate since no standard tests exist for them. In general, withdrawal forces for fasteners inserted perpendicular to the surface are much greater than those for fasteners inserted parallel to the surface. Specific nail holding power of particle board produced in Germany for high quality furniture ranges from 350 to 430 psi for nails inserted perpendicular to the surface of board (board density: 36 to 39 lb per cu ft).

Finishing—Composition board, being a wood product, will take almost any kind of finish used for wood. Conventional finishes include stains; shellacs; lacquers; and rubber, oil, water-base and textured paints. Special finishes include acid and alkali resistant coatings; metallic, multicolor, nonskid and wrinkle paints; lithographing; silk screen printing; decals; and flocked fiber coatings.

Many producers have available from stock a wide variety of prefinished board. Some types make use of the naturally attractive appearance of the wood particles, fibers or shavings. Other types have a variety of effects in veneer, including ribbed or perforated surfaces. Still other types are available with special treatments to permit easy cleaning and provide resistance to penetration by moisture, oils and other staining fluids.

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National Starch Products Inc.
Nu-Ply Corp.
Pacific Power & Light Corp.
Roddis Plywood Corp.
U. S. Gypsum Co.
U. S. Plywood Corp.
Wabash Screen Door Co.

Hot working is usually necessary but . . .

Molybdenum Parts
Are Not Hard to Make

This material, which has excellent hot strength, is available in all common forms except castings.

by Raymond W. Yancey, *Fansteel Metallurgical Corp.*

■ Molybdenum parts can be produced by most of the common fabrication methods as readily as parts can be produced from the more common metals. However, the limitations of the metal must be considered. By working at moderate and elevated temperatures, parts can be produced by forming, stamping, deep drawing, spinning, and forging. Castings of shapes other than simple ingots are still to be developed.

Workability—in general

In designing parts and developing methods for fabricating them, the mechanical and fabricating properties of molybdenum must be considered. The elevated temperature strengths shown in Fig 1 indicate that high strength tool materials are required for such operations as forging, severe forming or deep drawing.

Workability, as indicated by reduction in area and elongation (Fig 1), is increased considerably when the temperature of the metal is raised only a few hundred degrees. However, temperatures required are usually within the limits of commercial tool and die lubricants. For example, thin sheet can be worked at room temperature, but it is safer to work molybdenum up to 0.025 in. thick at temperatures in the 120 to 400 F range.

When working with molybdenum at elevated temperatures, it must be borne in mind that molybdenum's thermal conductivity (68 Btu/hr/sq ft/ft/°F) is high and its specific heat (0.06 Btu/lb/°F) low in comparison with steel. From a practical standpoint, this means that molybdenum loses its heat rapidly and hot working must be done quickly.

Hot work steels, cobalt-chromium-tungsten alloys or tungsten carbide tools and dies, lubricated with graphite, are generally used for working temperatures above 572 F.

Forming

In common metals, an equiaxed grain structure with minimum directional properties is desirable

Editor's Note

This article brings up to date the information in an article published in 1950 (MATERIALS & METHODS, July '50, pp 45-8).

for forming sheet. In molybdenum, however, the cold worked and stress relieved structure shown in the accompanying photograph can be worked far better than a completely recrystallized grain structure. Although a recrystallized structure is undesirable, sheet for deep drawing should be cross rolled and given a stress relief heat treatment. Since coil strip is rolled in only one direction, it has highly directional properties and is not recommended for severe deep drawing operations. Coiled strip can be bent into varied shapes if bending is done at 90 deg to the rolling direction.

Molybdenum parts formed from sheet metal are usually designed to be fabricated by bending, expanding, forming, drawing or spinning. In deep drawing, as in deep drawing of other metals, die radius, punch radius, clearance between work and tools, blank hold-down pressure, uniformity of sheet thickness, grain size, and temperature at which the metal is drawn should be closely controlled. Hydraulic presses having adjustable air pressures on the hold-down pad are preferred to crank-type presses. Aluminum bronze tools, or inserts located at points of greatest friction, are highly recommended in the low temperature ranges. Satisfactory lubricants range from castor oil to graphite, and include some proprietary compounds.

Electronic tube parts are produced regularly from 0.005 to 0.060-in. sheet by punching, stamping and forming. Molybdenum sheet can be perforated by gang punching, and expanded by conventional methods.

Molybdenum parts are spun on conventional spinning lathes, by normal methods, although the metal must be heated to the optimum temperature for the thickness of the sheet. This temperature may be as low as 300 F or as high as 1475 F. For sheet from 0.010 to 0.020 in. thick, a temperature of 300 to 400 F should be satisfactory. Sheet 0.025 to 0.040 in. thick must be heated between 400 and 925 F. For heavier sheet and plate, temperatures up to 1475 F may be necessary. Heat is usually applied by means of gas flames or an acetylene torch as the metal is being spun.

Forging and extruding

Molybdenum can be forged readily. Since forging enhances mechanical properties, reduces machining operations and saves metal, this fabricating method can often be used advantageously in forming molybdenum parts.

The ease of flow of molybdenum is indicated by the photograph of

Uses of Molybdenum

Here is a brief summary of the principal applications of molybdenum:

1. Wire is used for grids, support wires and glass-to-metal seals in electronic tubes. Also: mercury switch electrodes, electric furnace windings and metal spraying.

2. Shanks of cutting tools and boring bars take advantage of the high modulus of elasticity of molybdenum to minimize chatter and eliminate tool marks.

3. Some types of gyroscope rotor assemblies that require acceleration to operating speeds in minimum time use molybdenum shafts to reduce vibration and twist.

4. Electrical contacts are produced from molybdenum powder parts in combination with metals such as silver.

5. Filters and brush type contacts have been made from fibrous molybdenum particles.

6. Constructional materials for handling liquid metals such as lead, bismuth, lithium, sodium or sodium-potassium alloys are future possibilities.

7. Blades and I-beams (see photo on next page) are made from laminated sheet. Slabs and sheet produced from laminated ingots can be fabricated into sheets that may have future economic value in production of low cost, high temperature parts.

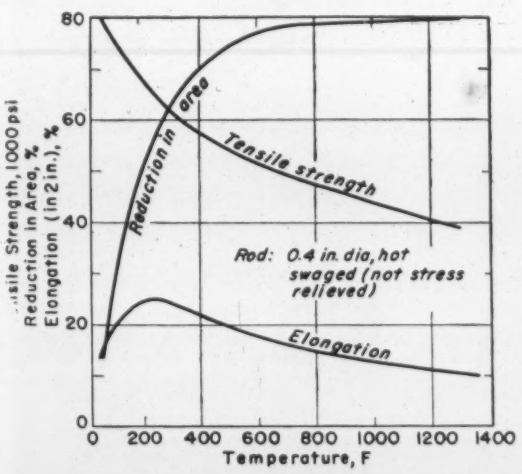


Fig 1—*Tensile properties of hot swaged molybdenum rod.*

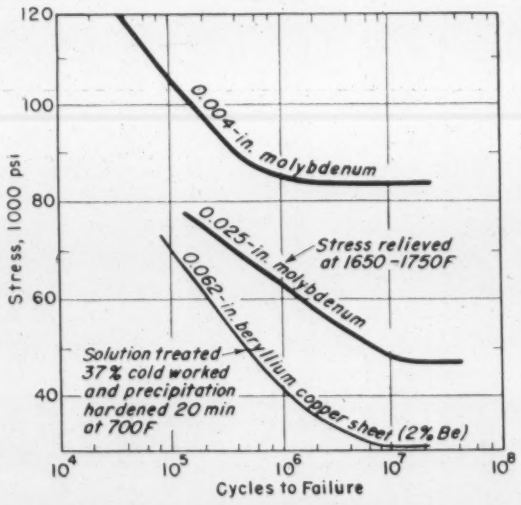

Stress, 1000 psi
0.004-in. molybdenum
0.025-in. molybdenum
Stress relieved at 1650-1750F
0.062-in. beryllium copper sheet (2% Be)
Solution treated 37% cold worked and precipitation hardened 20 min at 700F
Cycles to Failure

Fig 2—*Fatigue properties of molybdenum and heat treated beryllium copper.*

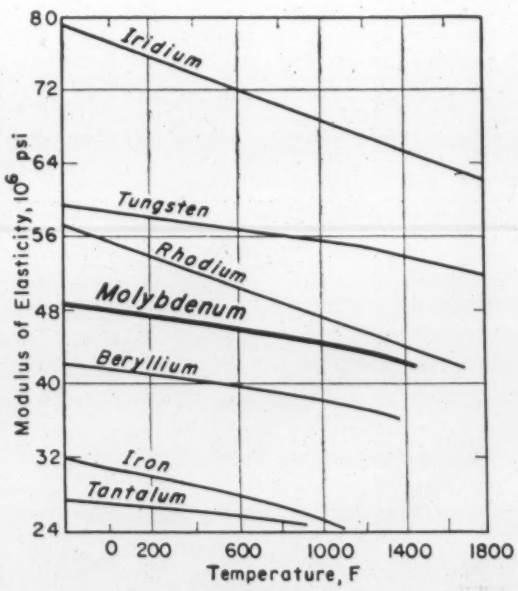
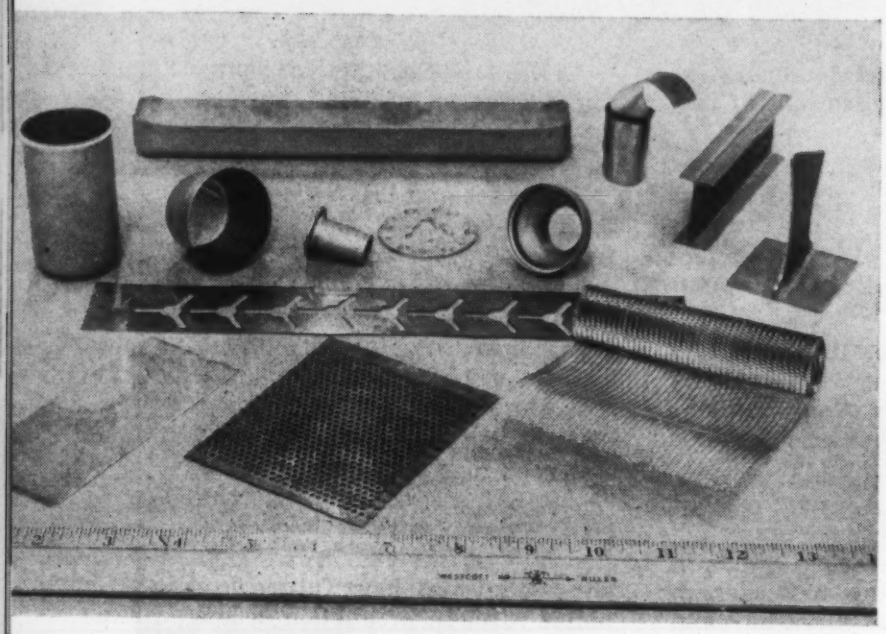
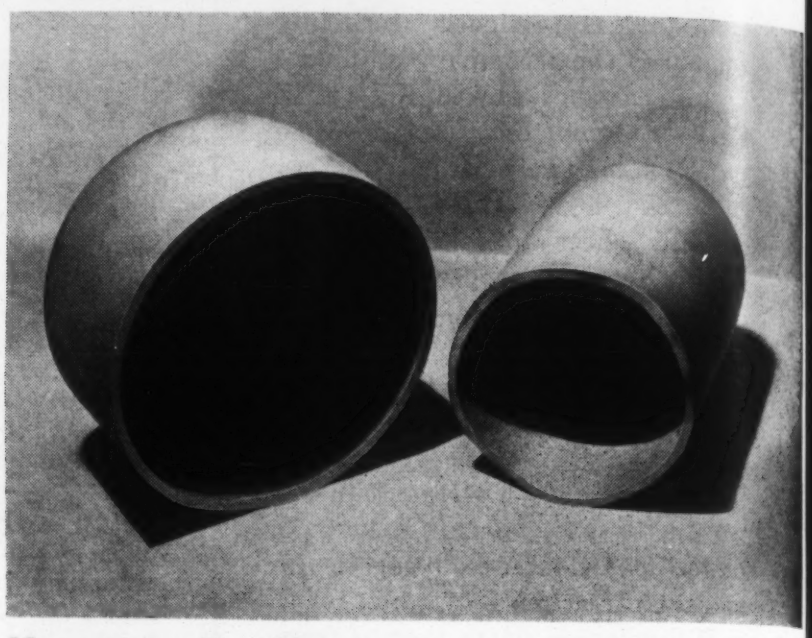


Fig 3—*Modulus of elasticity of molybdenum and other metals at elevated temperatures.* (W. Koster, Z. Metallkunde, vol. 39, 1948, pp 1-9)

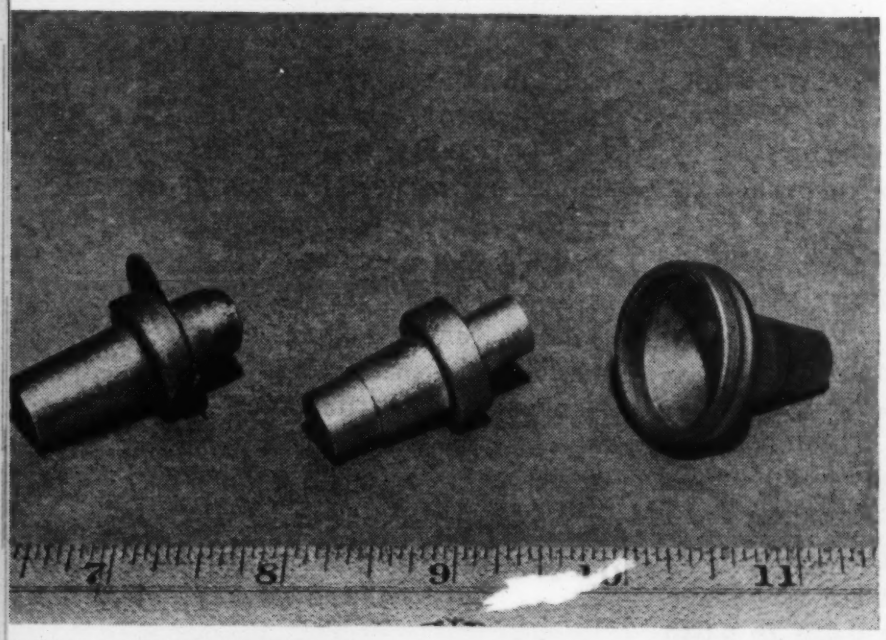
COMMON FORMS OF MOLYBDENUM INCLUDE . . .



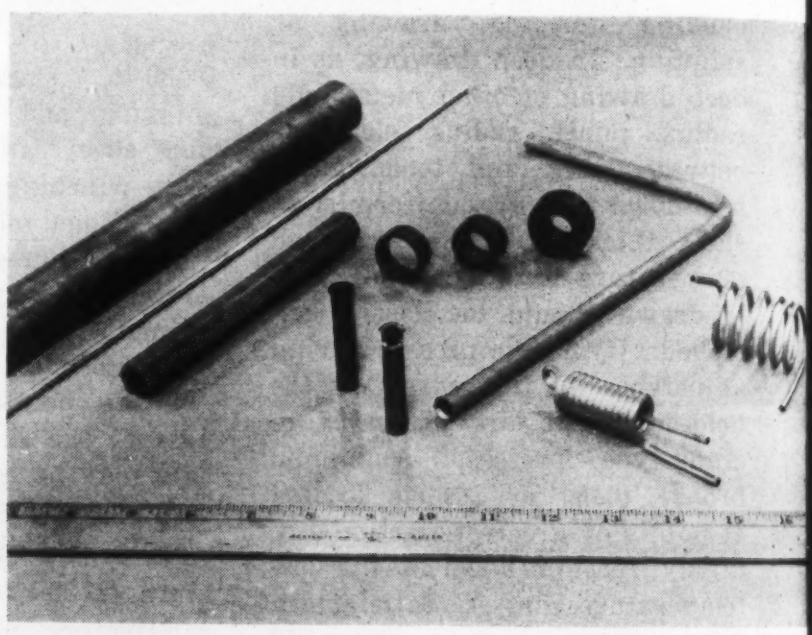
Sheet metal parts



Heavy wall cups

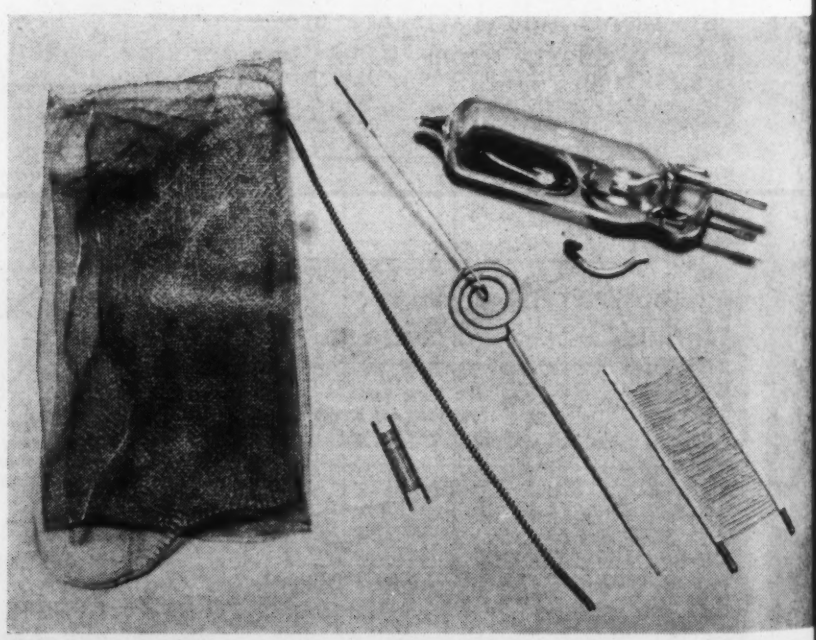


Forged parts



Extruded parts

Machined parts



Wire parts

upset forged parts on page 114. In producing one of these parts, the work was misaligned in the tooling and flash was produced. This flash is 3/16 in. long by 0.025 in. thick. Flow of this extent indicates that it should not be difficult to produce a variety of forged parts from molybdenum.

Extruded parts are also produced readily. Molybdenum seamless tubing, for example, is produced from machined billets that are hot extruded into round tubular sections on a production basis. Hexagonal tubing and other special shapes have been extruded experimentally. Seamless tubing is available in outside diameters as small as 0.060 in. and wall thicknesses as small as 0.006 in. Molybdenum tubing has also been clad with other metals such as stainless steel, copper and chromium-iron alloys.

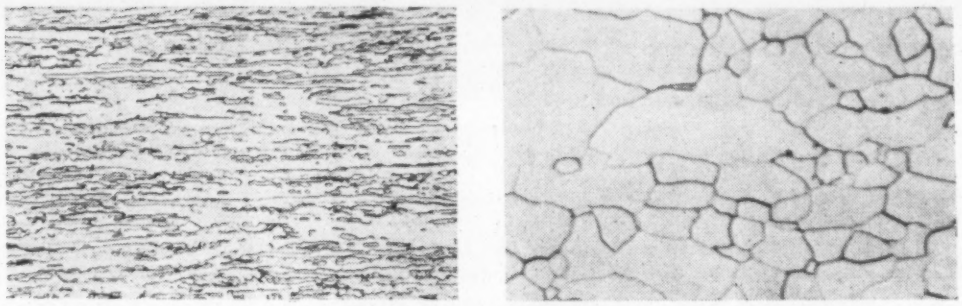
Depending on its function in various applications, tubing can be formed, coiled, flared, upset, or machined. Forming or coiling should be done at temperatures of 750 to 930 F.

Wire forming

Molybdenum wire is commonly used in diameters ranging from 0.080 in. to 0.001 in. The forming of wire parts presents no unusual difficulties. Properly processed molybdenum wire for electronic tube grids has a low yield-to-tensile strength ratio to allow for the calculated deformation that sets the grid at its predetermined dimensions. High tensile strength is required to prevent breakage in the deforming operation.

With its high modulus of elasticity (see Fig 2), high (but controllable) yield strength, good elevated temperature properties, low coefficient of expansion and good electrical conductivity, molybdenum possesses a number of advantages for spring parts in mechanisms operating at temperatures where springs made of common metals start to fail, or in some corrosive atmospheres. The endurance limits of molybdenum shown in Fig 3 indicate that the metal could be used in spring designs requiring good fatigue properties.

Structure Makes a Difference



YES NO

Cold worked and stress relieved structure shown at left is required for good deep drawing properties in molybdenum sheet. Recrystallized structure (at right) is subject to brittle failure in deep drawing. (250X)

Powder metallurgy

The simplest form of molybdenum metal is powder. The powder is used primarily for the manufacture of ingots, made by compacting and sintering. However, powder can be the starting point in the design of parts. In fact, molybdenum powder has been rolled directly into strip. Powder may be shaped into various other forms by compacting with punches and dies, hydrostatic compacting in rubber molds, powder spraying or slip casting.

Pure molybdenum powder is sometimes mixed with other metal powders in the manufacture of products having specific electrical characteristics or to form an alloy or intermetallic compound. Other powders may be added to produce a porous structure, the added materials being entirely removed in subsequent operations such as vacuum sintering or hydrogen firing.

Joining

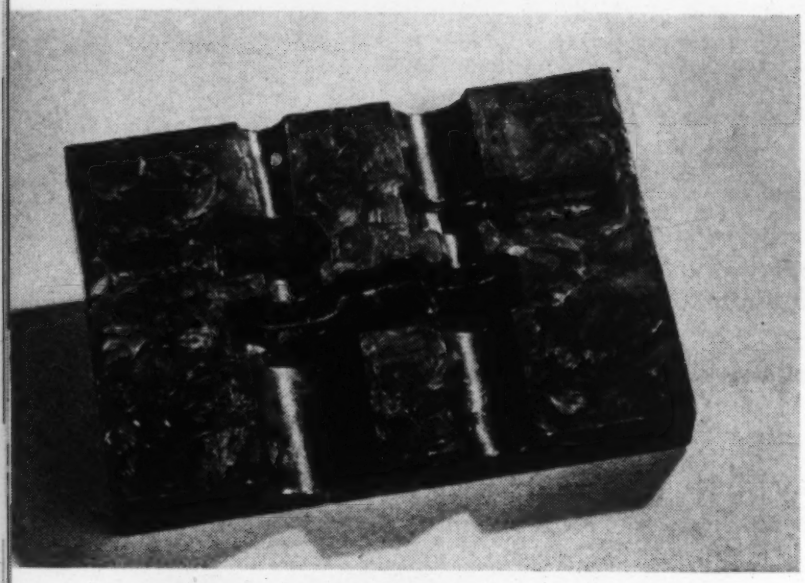
Mechanical joining by rivets, bolts, or crimping is a widely used method of fabricating molybdenum. Brazing must be done with silver alloys, copper, nickel or special alloys, the choice depending on the service temperature to which the parts will be subjected. Fluxes may or may not be necessary. Most brazing of molybdenum assemblies is done in furnaces with a reducing or inert atmosphere, and fluxes are not used when parts are sufficiently cleaned beforehand.

Molybdenum electronic tube components are often spot welded. Overlapping joints in thin sheets are preferably made with a dimple in the surface of one of the sheets; the resulting projection type weld is superior to an ordinary spot weld on flat sheet. Sections of heavier wall thickness, 0.025 in. and over, are usually edge or butt welded by the inert-gas-shielded arc method with no deposited filler metal.

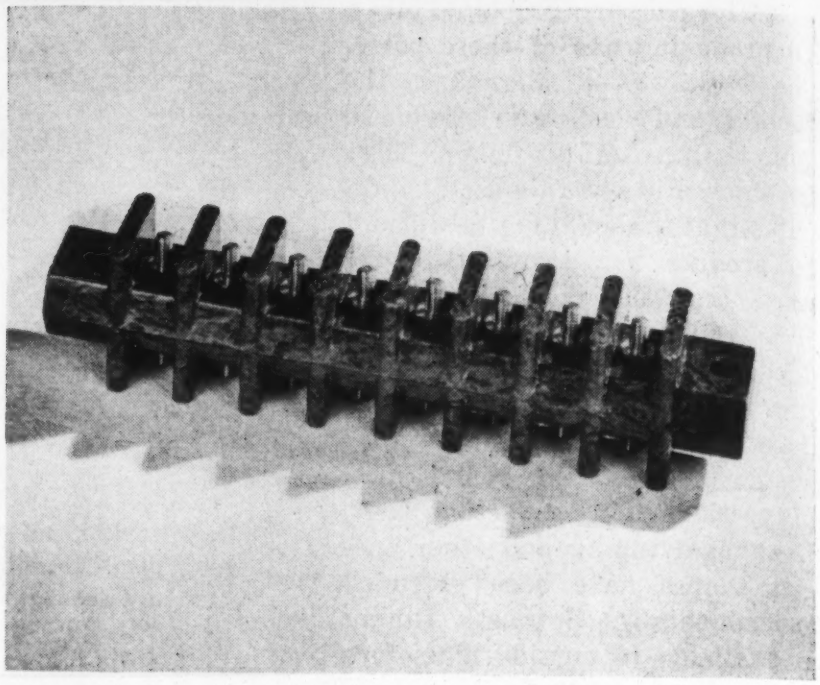
Machining

As a general rule, fine finishes and close tolerances are essential on machined molybdenum parts, especially those used in electronic tubes. For turned or milled parts, high speed steel or cemented carbide tools are used, the choice depending on production quantities. Carbide grades suitable for cast iron are equally suitable for molybdenum, and the same speeds, clearance and rake angles are usually applicable.

In drilling or tapping it must be realized that the coefficient of expansion of the tool is greater than that of molybdenum, and the tool must be kept cool to prevent seizing. Until recently, cutting fluids composed of 60 carbon tetrachloride and 40% oil were considered satisfactory, but trichloroethane has replaced carbon tetrachloride because of its lower toxicity.



Foundry core drier *must withstand elevated temperatures, be tough enough for normal foundry handling.*



Terminal strip *must have good electrical qualities, high strength, temperature stability.*

When to Specify Phenolic-Glass Moldings

by P. Fina, *Fiberite Corp.*

Timing gear *for a car must have high strength, resistance to impact.*

All photos courtesy Bakelite Co.

One-way valve *used in bottom of oil wells must have high mechanical strength, resistance to chemicals and erosion.*

TABLE 1—TYPICAL PROPERTIES OF PHENOLIC-GLASS

Property	Two Step[a]	One Step[b]	Modified[c]
Impact Str (Izod), ft-lb/in.	18.0	18.0	20.0
Flexl Str, 1000 psi	24	21	23
Flexl Mod, 10^6 psi	3.0	3.5	—
Ten Str, 1000 psi	11	9	9
Compr Str, 1000 psi	36	20	30
Water Abs (24 hr, 73 F), %	0.10	0.85	0.30
Coef of Friction	0.221	0.175	0.191
Dielec Str, v/mil			
Short-Time (dry)	395	110	250
Short-Time (wet)	385	—	—
Step-by-Step (dry)	345	75	—
Step-by-Step (wet)	345	—	—
Dielec Const (1 meg)			
Dry	5.7	6.3	7.4
Wet	5.7	—	—
Power Factor (1 meg)			
Dry	0.017	0.066	0.040
Wet	0.020	—	—
Mold Shrinkage, 10^{-4} in	6	4	0–2
Heat Dist Temp F	600	600	500

[a]Fiberite No. 4030-190.
[b]Fiberite No. 4031.
[c]Fiberite No. 4035.
[d]All samples surface ground on Simonds No. 46 wheel. Dragging surface: polished marble.

TABLE 2—GOVERNMENT SPECIFICATIONS FOR REINFORCED COMPOUNDS[a]

Specification	Designation and Type	Approx Izod Impact Str, ft-lb/in.	Reinforcement
MIL-M-14	CFI 5	0.6	Flock—wood or cotton
	CFI 10	1.0	Fabric—lightwieght; threads and sisal also used
	CFI 20	2.0	Fabric—heavyweight canvas
	CFI 30	3.2	Cord—usually tire cord
	CFI 40	4.2+	Cord—highly reinforced; sometimes nylon is used
MIL-M-19536	GPI 100	10.0+	Glass fiber
MIL-M-14	MFI 10	1.3	Asbestos—cord or fabric
	MFI 20	2.3	Asbestos—higher content than MFI 10
	CMI 5[b]	0.6	Fabric—lightweight
	MMI 30[b]	3.2	Glass fiber
	MAI 60[c]	8.0	Glass fiber
MIL-P-10420 (Ord)	Class 4	0.8	See CFI 5 and 10
	Class 5	1.75	See CFI 20
	Class 6	4.0	See CFI 40
	Class 7	0.64	See MFI 10
	Class 9	0.64	See MFI 10 (ASTM-B-700-52T)
	Class 12	0.46	See CFI 5 (usually paper pulp)

[a]Resin is phenolic except where noted. [b]Melamine. [c]Alkyd.

TABLE 3—FLEXURAL AND SHEAR PROPERTIES—A COMPARISON

Compound		Flexural Strength, 1000 psi	Flexural Modulus, 10^{-6} psi	Shear Strength, 1000 psi
Resin	Reinforcement			
Phenolic	Glass	18-24[a]	2.9-3[a]	17.8
	Sisal[b]	8.5-13.5	1.1-1.4	10
	Asbestos	18.2	1.6	14.4
	Fabric	14.5	1.4	13.6
	Cord	15	1.4	14.4
Polyester	Glass	12.7-13[a]	2.3-1.4[a]	9.6
	Sisal[b]	3.7-8.0	0.9-1.5	6.3
Melamine	Glass	18.3	2.6	—
Alkyd	Glass	20.1	2.2	—

[a]Lower value for ½-in. fiber length; higher value for 1-in. fiber.
[b]Spread of property ranges covers several formulations.

The parts shown here are good applications for glass-reinforced phenolic moldings. The data in this article will help you solve other problems with these specialized materials.

■ The outstanding properties of phenolic-glass compounds in comparison with other molding materials are 1) resistance to high and low temperatures, 2) high tensile and flexural strengths, 3) high impact resistance, 4) good dimensional stability, and 5) good resistance to deformation under load. In common with other phenolic compounds, phenolic-glass has good aging characteristics, extremely low mold shrinkage, a hard surface, good dielectric properties, and moderately good flame resistance.

Limitations on the use of phenolic-glass compounds are similar to those of any phenolic molding material. They include: 1) limited choice of colors, 2) variable arc resistance, 3) poor resistance to strong alkalis, and 4) darkening of color on exposure to sunlight.

Phenolic-glass compounds are available with one or two-stage type resins or with resins that have been modified to enhance specific properties. The one-stage type cures faster, has a glossier surface and differs from the two-stage in chemical properties. Two-stage types generally have better electrical properties and longer shelf life. Table 1 lists typical properties of representative glass-filled compounds made of the three types of resins. These values are for specific commercial grades, and are somewhat higher than

TYPICAL PROPERTIES OF REINFORCED COMPOUNDS

Resin ➤	Polyester		Phenolic				
Reinforcement ➤	Sisal[a]	Glass[b]	Glass	Asbestos Yarn	Chopped Fabric	Cotton Cord	Sisal[a]
Specific Gravity	1.55-1.82	1.85-1.94	1.7-1.73	1.65-1.68	1.36-1.38	1.35-1.37	1.30-1.65
Flexural Strength, psi	3750-8050	12,700-13,000	18,700	18,200	14,500	15,000	8,500-13,500
Flexural Modulus, 10^6 psi	0.89-1.49	1.46-2.33	2.85	1.0	1.0	1.0	1.08-1.35
Tensile Strength, psi	2600-3200	4500-5100	8800	9000	7500	8100	3900-5500
Compressive Strength, psi	13,500	16,500-17,500	27,000	25,500	27,500	21,000	26,000
Shear Strength, psi	6000-6500	8800-9600	17,800	14,400	13,600	14,400	10,000
Impact Strength (Izod), ft-lb/in. notch	1.66-2.47	2.83-3.03	12.6	4.1	2.45	5.94	1.4-1.77
Water Absorption (24 hr), %	0.87-1.98	0.43-0.54	0.10	0.30	0.60	1.8	0.59-0.93
Heat Distortion Temp (264 psi), F	302	—	>600	351	325	300	330-347

[a]Spread in property ranges results from combining values for several grades, each containing different proportions of resins and reinforcement.
[b]Property ranges cover two compounds with different resin-glass ratios.

GENERAL PROPERTIES OF UNFILLED RESINS

Resin ➤	Polyester	Phenolic	Melamine	Epoxy[a]
Flame Resistance	Burns[b]	Self-extinguishing	Self-extinguishing	Burns
Effects of:				
Sunlight	Chalks	Darkens	Slight	None
Weak Acids	Slight	None—slight	None	None
Strong Acids	Attacked	Variable	Decomposes	Variable
Weak Alkalis	Attacked	Slight	None	None
Strong Alkalis	Attacked	Attacked	None—slight	None
Hardness (Rockwell)	M110[c]	M116	M123	—
Major Limitation	High shrinkage	Limited colors	High shrinkage	Difficult to release from mold
Major Advantage	Low pressure molding	Heat resistance	Arc resistance	Low shrinkage

[a]Epoxy molding compounds are under development.
[b]Flame resistant grades are available.
[c]Alkyd type.

alkyds and other polyesters. Reinforcements include chopped glass, sisal, asbestos, and cotton fibers; and chopped cord or fabric made from these fibers. An accompanying table compares general properties of several polyester compositions with those of several phenolic compounds. Values for the most part are relatively conservative and are intended only to give a general comparison. A second table compares general properties of four resins used in the compounds. The epoxy is included because an epoxy molding material is now under development.

In selecting a reinforced thermosetting molding compound, the design engineer should carefully investigate each type. Each combination of resin and reinforcement provides unique physical, mechanical, electrical and chemical properties, as well as distinct molding characteristics. Proper evaluation will generally point to the one type that can best satisfy individual design requirements. The purpose of this article is to point out the combination of properties, and the design potential, peculiar to glass-reinforced phenolic molding compounds; and further, to indicate where they fit in the array of reinforced molding materials which can be specified.

Which Reinforced Molding Compound?

Terminology in the reinforced plastics molding industry is far from standardized. Reinforced molding compounds discussed in this article refer to materials consisting of resins in which chopped fibrous reinforcements have been mixed prior to molding. The term "premix" molding materials has come to be associated with the fluid-type alkyd-glass compositions used for "gunk molding"; the term "wet mix" molding materials has been associated with materials like phenolics and other compounds where the reinforcement is mixed into the fluid resin, and the compound is subsequently dried and sold as a dry molding material. In this article all these reinforced thermosetting materials are referred to simply as molding compounds, and designated by resin type and reinforcement type.

A wide variety of reinforced thermosetting molding compounds is now available. Resins include phenolics, melamines,

the more conservative general values given in the table above.

Phenolic-glass compounds have design characteristics similar to those of any phenolic compound. Thus the emphasis in this article will be on properties, in order to indicate what specific problems these materials can solve.

Mechanical strength

Fibrous reinforcements provide the relatively brittle thermosetting resins with mechanical strength and resistance to impact. The degree of strength contributed by the reinforcement is dependent on the inherent strength of the reinforcing material and

the degree of adhesion between the resin and the reinforcement. Also, of course, the percentage of inert fillers (used primarily to reduce costs and to enhance certain properties such as heat resistance, wear and surface gloss) will affect mechanical strength of the molded part to a degree.

In general order of increasing strength, reinforcing materials used in molding compounds are 1) cotton flock, 2) nylon flock, 3) cotton fabric, 4) asbestos cord, 5) sisal, 6) cotton cord, 7) nylon cord, and 8) glass fibers or chopped glass cloth. This may not be the exact order of strength in all cases, since sisal, asbestos cord and cotton fabric are available in different strengths. All things being equal, glass fibers generally provide compounds with highest mechanical strengths.

Izod impact strengths of phenolic-glass compounds are among the highest for reinforced molding materials, ranging from 12 to 20 ft-lb per in. notch. Table 2 lists government specifications for these materials and minimum Izod impact values called out by the specifications. The 10 ft-lb per in. minimum value given for phenolic-glass is the highest listed.

Table 3 compares shear strength and flexural properties of phenolic-glass with those of several other phenolic, polyester, melamine and alkyd compounds. Reinforced with the 1-in. glass fiber, phenolic-glass has a flexural strength of 24,000 psi, a flexural modulus of 3 million psi, and a shear strength of 17,800 psi, all three values being the highest listed. The compounds that most closely approach phenolic-glass in these respects are the alkyd and melamine-glass materials.

Though data are somewhat limited on resistance to deformation under load, some indication of this property can be gained by comparing elongation at break of phenolic-glass with that of other compounds (see Table 4). The low value of 0.2% for phenolic-glass, coupled with the high ultimate strength of the material, indicates a relatively rigid nature, with good resistance to deformation under load.

Effects of temperature

Elevated temperatures — Although "elevated temperatures" is a relative term, in the context of organic plastics, phenolics are among the most heat resistant; and of the reinforced phenolics, the glass-reinforced phenolics are most heat resistant.

ASTM heat distortion temperatures (264 psi stress) of 600 F have been recorded for phenolic-glass compounds, and such materials have been used continuously at temperatures ranging from 450 to 600 F in a lightly stressed condition. Table 5 compares heat distortion temperatures of phenolic-glass with those of several other compounds and also shows effects of 24-hr exposure at 500 F on flexural strength of phenolic-glass, polyester-glass and silicone-glass.

At temperatures of 600 to 800 F, intermittent exposure causes some blackening or some surface degradation of phenolic-glass, but most properties are retained to some degree. After extremely short exposures at temperatures up to 1500 F, and exposures for a matter of seconds at 7000 F, phenolic-glass parts retain their general form, though they are considerably eroded or shrunken. This type of heat resistance makes phenolic-glass useful as liners for rockets and missiles, where actual burning time is extremely short. After the rocket burns out, the phenolic-glass liner is charred and eroded, but it withstands the heat sufficiently to protect the metal.

Low temperatures — Phenolic-glass compounds have good me-

TABLE 4—ELONGATION AT BREAK—A COMPARISON

Compound		
Resin	Reinforcement	Elongation, %
Phenolic	Glass	0.2
	Fabric	0.4
Melamine	Fabric	0.6
Polyester	Glass	0.5–5.0

TABLE 5—HIGH TEMPERATURE PROPERTIES

Resin and Reinforcement	Retention of Flex Str, %[a]	Heat Dist Temp, F
Phenolic		
Glass	80	600
Sisal	—	347
Asbestos	—	351
Fabric	—	325
Cord	—	300
Polyester		
Glass	34	400
Sisal	—	300
Silicone (glass)	50	—
Epoxy	—	130–365
Melamine	—	400

[a]After aging for 24 hr at 500 F.

TABLE 6—EFFECT OF LOW TEMPERATURES ON MECHANICAL PROPERTIES
(Deviation from room temperature values)

Resin ➔	Phenolic				Melamine	Alkyd
Reinforcement ➔	Glass[a]	Glass[b]	Fabric or Cord	Fabric (bearing grade)	Glass	Glass
Deviation of Tensile Strength, %						
–20 F	+12	+14	—	+13	—	—
–40 F	+ 5	+ 3	+10 to +14	+ 7	–11	+46
Deviation of Flexural Strength, %						
–20 F	+0.3	+11	—	⅝ 1	—	—
–40 F	+4	+15	—	– 1	—	—
Deviation of Impact Strength, %						
–20 F	+16 to +37	+10	—	–26	—	—
–40 F	+29 to +40	+29	–30 to –35	–30	0	0

[a]Fiber length of ⅝ in.
[b]Fiber length of 1 in.
Source: All values except those for phenolic-glass and phenolic bearing grade taken from data of Office of Technical Services, Dept. of Commerce.

chanical properties after exposure to low temperatures. Table 6 shows effects of exposure to temperatures down to —40 F on impact, flexural and tensile strengths of two phenolic-glass compounds and a phenolic-fabric compound. In all cases, strengths of phenolic-glass were improved by low temperature exposure.

TABLE 7—A COMPARISON OF THERMAL EXPANSION

Phenolic-Glass Premix	$6.6\text{-}8.3 \times 10^{-6}$
Polyester-Glass Premix	11×10^{-6}
Steel	$6\text{-}7 \times 10^{-6}$
Aluminum	$12\text{-}13 \times 10^{-6}$
Cast Iron	5.9×10^{-6}
Brass	9.6×10^{-6}

TABLE 8—A COMPARISON OF WEAR AND ABRASION RESISTANCE

Resin and Reinforcement	Depth of Wear, in.[a]	Abr Res, % loss in wt[b]
Phenolic		
Glass	0.052	34.9
Asbestos	0.032	24.0
Nylon	0.037	—
Fabric	0.042	17.6
Fabric[d]	0.017	—
Sisal	0.059	11.3
Cord	0.067	16.9
Polyester		
Sisal	0.098	49.7
Glass	0.096[c]	60.6

[a]Tests run on ½ x ½ in. bars. Bearing pressure of 800 psi applied by 1.25-in. dia polished steel shaft rotating at 415 sfm. Water coolant at 77 F was used for duration of 24-hr test.
[b]No. 40 steel grit used for the 1-hr test.
[c]This depth reached in 10 min—test discontinued.
[d]Bearing grade.

Other properties

Table 7 compares linear coefficients of thermal expansion of several materials. The similarity between expansivities of phenolic-glass and of steel can be used advantageously when designing for steel inserts. When using aluminum inserts, the disparity between expansivities must be taken into account.

Bearing properties of standard phenolic-glass compounds, as indicated by coefficient of friction and resistance to wear and abrasion, are moderately good. Coefficient of friction, as shown in Table 1, ranges from 0.175 to 0.221. These values compare with 0.201 to 0.229 for phenolic-fabric. Table 8 compares resistance to wear and abrasion of phenolic-glass with values for several other materials. The phenolic-fabric, both in the standard grade and the bearing grade, is better than phenolic-glass. The abrasive action of the glass fibers probably accounts for the relatively poor showing of phenolic-glass in this respect.

Flame resistance of phenolic-glass is relatively good, as shown in Table 9. Ignition time is longer than that of phenolic-cord and phenolic-fabric, about the same as that of phenolic-asbestos and melamine-cellulose, but shorter than that of melamine-asbestos and melamine-glass. Once ignited, phenolic-glass burns more slowly than phenolic-asbestos, melamine-cellulose, melamine-asbestos and melamine-glass but more rapidly than phenolic-cord and phenolic-fabric.

TABLE 9—FLAME RESISTANCE—A COMPARISON

Compound		Gov't Spec		Ignition Time, sec	Ignition Temp, F	Burning Rate, sec
Resin	Reinforcement	MIL	Type			
Phenolic	Glass[a]	GPI	100	130-225	930+	110-120
	Cord	CFI	40	60-90	525-660	270-300
	Fabric	CFI	20	90-120	660-760	240-330
	Asbestos	MFI	10	120-240	760-1040	60-180
Melamine	Cellulose	—	—	120-270	760-1050	30-60
	Asbestos	—	—	120-600+	760-1110+	40
	Glass	—	—	240-600+	1040-1110+	30-60
Polyesters[b]	All	Many types ignite and burn quite readily. Burning rate varies for specimens under 0.050 in. from 1.5 sq in. per min to self-extinguishing				

[a]Tested separately; results are relative.
[b]Burning rate taken from *Technical Data on Plastics*, 1957, published by Manufacturing Chemists Assn.
Source: R.I. 4134—Bureau of Mines, Dept. of Interior.

Cost considerations

From the standpoint of cost-per-unit-volume, phenolic-glass compounds fall about in the middle of the reinforced compound price range. They are less costly than melamine-glass, alkyd-glass, silicone-glass and some high glass content polyester compounds. They are more costly than melamine-fabric, polyester-sisal, low glass content polyester compounds, and most other phenolic compounds.

Of course, in considering the economics of materials selection, generally the stronger the material, the thinner the section. Where this rule can be applied, the strength of phenolic-glass can bring about reduced materials costs and reduced cure time, which means reduced cycle time.

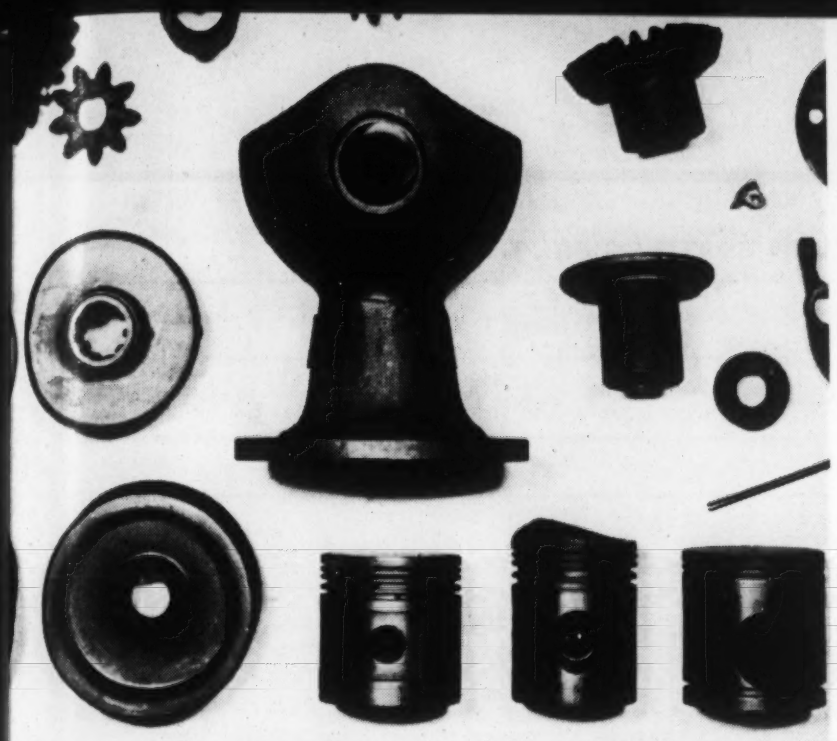
Another cost consideration is the accuracy to which a part can be molded. The higher the degree of accuracy in the as-molded shape, the less machining and finishing will be required. The critical accuracy of dimensions of phenolic-glass parts depends more on accuracy of mold dimensions than on shrinkage, since compounds (particularly one-stage types) prepared for close tolerance molding can exhibit mold shrinkage as low as zero to 0.0002 in. Shrinkage of two-stage phenolic-glass compounds will be somewhat higher, as shown in Table 1. Accuracy of phenolic-glass parts depends to a great extent on mold design and pressure, and on the molding control and technique used by the molder.

Acknowledgment

The author would like to thank J. E. David, R. Werkheiser, P. Bury and D. Schmanski of Fiberite Corp. for assistance in gathering data and preparing the manuscript.

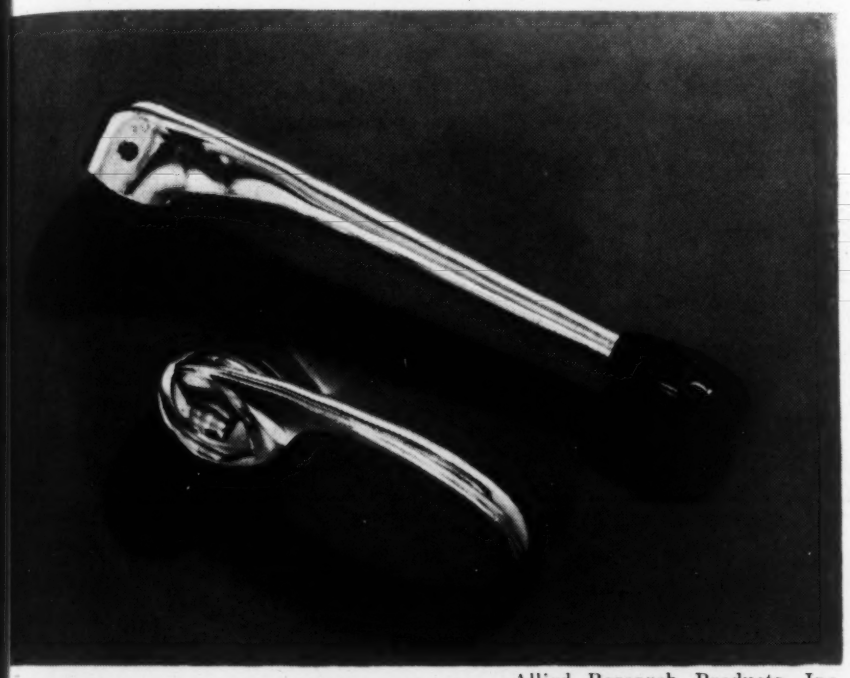
Reference

Werkheiser, R. L., "Comparative Mechanical Properties of Polyester And Phenolic Based Premix Compounds," presented at the 12th Annual Technical and Management Conference of the Reinforced Plastics Div., Society of the Plastics Industry, Feb '57.



Parker Rust Proof Co.

Phosphate coatings



Allied Research Products, Inc.

Chromate coatings

Aluminum Co. of America

Anodized coatings

Materials
in Design Engineering

Manual No. 140—August 1957

All of the many inorganic conversion coatings are covered in this comprehensive 16-page report. Applied by chemical and electrochemical means, these coatings are relatively low in cost and are used on many common metals to —

1. *Improve paint bonding*
2. *Provide corrosion resistance*
3. *Decorate the surface*
4. *Aid in cold forming*
5. *Increase wear resistance*

Conversion Coatings for Metals

by Robert J. Fabian,
Associate Editor,
Materials in Design Engineering

WHY AND WHERE CONVERSION COATINGS ARE USED

Purpose	How the Coatings Compare	Metals That Can Be Coated[a]									
		Alumi-num	Cad-mium	Cop-per	Iron	Magne-sium	Silver	Steel	Tin	Tita-nium	Zinc
To Improve Paint Bonding											
Phosphate Coatings	Rough crystalline structure provides excellent paint adhesion. Better paint bond than chromate coatings. Corrosion confined to limited area when paint film is damaged	X	X		X	O		X	O		X
Chromate Coatings	Provide high corrosion protection because of nonporous structure. Paint adhesion not generally as good as with phosphate	X	X	O	O	X	O	O	O		X
To Improve Corrosion Resistance											
Anodic Coatings	Provide equal or better corrosion protection —at higher cost—than chromate coatings	X				X					O
Chromate Coatings	Coatings generally provide much better corrosion resistance than phosphate coatings. Nonporous structure acts as moisture barrier. If coating is broken, inhibiting action of soluble chromate retards corrosion of basis metal	X	X	X	O	X	O	O	O		X
Phosphate Coatings	Coatings not generally used alone for corrosion protection. Treated with oils, waxes or stains, however, provide good protection, especially on ferrous surfaces	X	O		X			X	O		X
Oxide and Other Coatings	Do not provide as much protection as other conversion coatings. However, cost is lower	O	O	O	O			O			O
For Decoration											
Chromate Coatings	Available in wide variety of natural and dyed colors. Colors are not as light-fast as colored anodic coatings	X	X	X	O	X		O	O		X
Anodic Coatings	Can be colored with a large variety of dyes and pigments. Underlying metal can be used to impart attractive metallic sheen. Sealing required	X				X					O
Phosphate Coatings	Have little decorative value except when painted	X	X		X	O		X	O		X
Oxide and Other Coatings	Black and blue-black coatings widely used to decorate ferrous, zinc and cadmium surfaces. Considerable number of colors producible on copper and aluminum	X	X	X	X			X			X
To Aid In Cold Forming											
Phosphate Coatings	By preventing metal-to-metal contact, lubricated coatings facilitate deep drawing, cold heading, extrusion, and wire and tube drawing	X			X			X			X[b]
Oxide and Other Coatings	Special coatings have been developed for titanium									X	
To Improve Wear Resistance											
Phosphate Coatings	Maintain continuous oil film between bearing surfaces; prevent welding of surfaces under load				X			X			
Anodic Coatings	Hard anodic coatings with greater thickness and weight than conventional anodic coatings used to increase wear and abrasion resistance	X				X					

[a]X—Metals most commonly treated for purpose listed. O—Metals less commonly treated. [b]Electroplates.

■ Chemical or electrochemical conversion coatings are formed by the modification of metal surfaces into an inert, inorganic film which is an integral part of the basis metal. Because of their unique combination of properties, these coatings are widely used for the protection and decoration of metal surfaces. Depending on the treatment selected, they can be used to: 1) promote paint bonding, 2) provide a decorative surface, 3) provide a protective barrier against corrosion, 4) facilitate cold forming, and 5) serve as an absorptive carrier for lubricants, thereby increasing wear resistance and facilitating break-in.

Phosphate Coatings

Phosphate coatings consist of crystalline salts of the metal being treated or of metal ions added to the phosphating solution. They are principally used on iron, steel, zinc and aluminum, and to a lesser extent on cadmium, tin and magnesium surfaces. The coatings are used chiefly to: 1) provide a paint base, 2) provide corrosion protection, 3) improve drawing, extrusion and cold forming, and 4) improve scuff and wear resistance.

Types of coatings

Phosphate coatings are generally produced in heated solutions containing phosphate salts, phosphoric acid and various accelerators. These solutions react with the basis metal and convert the surface into an inorganic layer. With the exception of amorphous phosphate coatings for aluminum, all phosphate coatings are crystalline in structure. Properties of the coatings depend largely on the size, uniformity and density of its crystals.

In general, the various phosphate coatings can be classified as follows:

Zinc phosphate (lightweight)—On iron or steel surfaces these coatings consist of a mixture of zinc phosphate and iron phosphate. A great many proprietary solutions are available for applying these coatings; typical is an accelerated zinc dihydrogen phosphate bath containing ferrous dihydrogen phosphate and phosphoric acid. The coatings can be applied in a matter of seconds in weights of up to about 150 mg per sq ft, and they are principally used as a paint base for less severe environments.

Zinc phosphate (medium weight)—These coatings have essentially the same structure as the lightweight coatings. However, because of their heavier weight (about 200 to 800 mg per sq ft), they possess better corrosion resistance and are more suitable as a paint base for severe environments. Lubricated medium weight coatings are also used as an aid in mild cold forming operations.

Zinc phosphate (heavy weight)—Heavy weight coatings (up to 4000 mg per sq ft) provide good corrosion protection when treated with a suitable rust preventive, oil or wax. Lubricated coatings with a uniform crystal structure also possess excellent frictional properties; for this reason they are used as an aid in cold forming operations and to improve wear resistance. Processing times of 10 to 30 min are required to apply these coatings.

Iron oxide phosphate — These coatings are characterized by their light weight (25 to 90 mg per sq ft) and, like the zinc phosphate coatings, are intended primarily as a paint base. Processing time is short. A typical bath consists of a dilute solution of an alkali metal phosphate plus suitable detergents.

Manganese phosphate—Because of their heavy weight (1000 to 4000 mg per sq ft), manganese phosphate coatings are quite suitable for improving corrosion protection, as well as the wear resistance and break-in of rubbing surfaces. The coating consists of a mixture of manganese and iron phosphate and is produced from a bath containing manganese and iron phosphates, phosphoric acid and accelerators. About 10 to 30 min are required for processing.

Amorphous phosphate — These coatings are primarily intended for use on aluminum surfaces to improve paint bonding. They are obtained by spraying or dipping in proprietary mixtures (such as the Alodine process) of chromic, phosphoric and hydrofluoric acids. Processing takes 15 sec to 2 min, and the coatings weigh from 100 to 200 mg per sq ft.

As a paint base

The popularity of phosphate coatings as a paint base derives from 1) the excellent mechanical

Parker Rust Proof Co.

Porosity of phosphate *treated steel surface is revealed in this 100X photomicrograph.*

adhesion provided by the large surface area, and 2) the pores and cavities in the phosphate crystal structure. A further advantage of the coating is that because of its chemically neutral structure it prevents electrochemical migration and confines corrosion to a limited area when the paint film is damaged.

Coatings in the weight range of 200 to 800 mg per sq ft are the most widely used paint-base phosphate coatings. Most of these medium weight treatments use zinc phosphate solutions and are applicable to iron, steel, zinc and cadmium surfaces. The solutions can be applied by spraying, dipping, brushing or swabbing (for 1 to 10 min) at temperatures of 70 to 210 F. A special phosphate treatment (Dow No. 18) is also available for touching up magnesium surfaces prior to painting.

The three principal types of lightweight phosphate coatings used as a paint base are: zinc (or zinc-iron) phosphate, iron oxide phosphate, and amorphous phosphate.

Zinc phosphate coatings (which weigh about 60 to 120 mg per sq ft) are normally applied during steel mill processing. These coatings have a fine crystal structure and can be formed either before or after painting without damaging the coating or the paint film.

Iron oxide phosphate coatings also have a very fine crystal structure; so fine, in fact, that they are frequently referred to as amorphous coatings. These coatings are usually produced by spraying and to a lesser extent by dipping.

Amorphous phosphate coatings have been widely used on aluminum surfaces. The coatings differ from conventional phosphate coatings in that they do not have a crystalline structure. The surface structure is dense, rather hard and apparently nonporous. Unlike most oxide films, these coatings are nonabsorptive and cannot be dyed or stained. Despite their smooth surface, these coatings provide a good paint bond.

As in any coating process, the success of a phosphate coating depends on the degree of surface preparation. Acid pickling, alkali derusting, emery cleaning or blasting with sand, grit or shot is used to remove scale and rust. Degreasing is usually accomplished with trichloroethylene, an emulsion cleaner or in a mild alkaline bath.

For corrosion protection

Unpainted phosphate coatings, treated with suitable oils, waxes or stains, also provide excellent corrosion protection, especially on ferrous surfaces. Coatings consisting largely of iron phosphate crystals were originally used for this purpose, but because of the long processing times required with the iron phosphates, zinc and manganese phosphate coatings are currently favored for corrosion protection. These coatings can be treated with any one of a number of dry film, soft film and nondrying rust preventive finishes and stains, depending on the end use.

The coatings are usually applied by immersion in weights of 800 to 2500 mg per sq ft. Weight of the coating is a function of immersion time, pretreatment, solution composition and basis metal. Metal parts that have been completely machined, and some stampings and pressed steel parts, may not require preliminary cleaning. However, rough castings and other parts coated with heavy scale, oil or grease require thorough cleaning. Application of the coating is comparatively simple; it requires about five steps, including cleaning and rinsing.

To aid cold forming

Because of their ability to carry lubricants, phosphate coatings can be used to improve various cold forming operations such as deep drawing, cold heading, extrusion, and wire and tube drawing. At various times all of the phosphate coatings have been used as aids in cold forming; however, zinc phosphate coatings are the most widely used.

Coatings have been used to improve the cold working of steel, zinc-coated steel, stainless steel, aluminum and zirconium. In most applications the coatings are impregnated with a soap solution or other lubricant prior to forming. During forming, the coating crystals are deformed or crushed and prevent metal-to-metal contact. As many as four successive draws have been made without intermediate annealing or relubrication. Since the coating is nonmetallic it acts as an antiflux and aids materially in preventing welding and galling. By aiding in cold forming, phosphate coatings provide longer tool life, fewer defects due to scratches, greater reductions, fewer draws and increased drawing speeds.

Wear resistance

Because of their crystalline structure, phosphate coatings are capable of maintaining a continuous film of oil between bearing surfaces. Oil-absorptive manganese phosphate coatings are produced by treating parts in a bath of metal acid phosphates containing free phosphoric acid and accelerators. Time required for treatment and weight of the coating are considerably higher than for paint-base phosphate coatings. Typically, a treatment used to produce coatings of 1000 to 4000 mg per sq ft requires about 10 to 30 min.

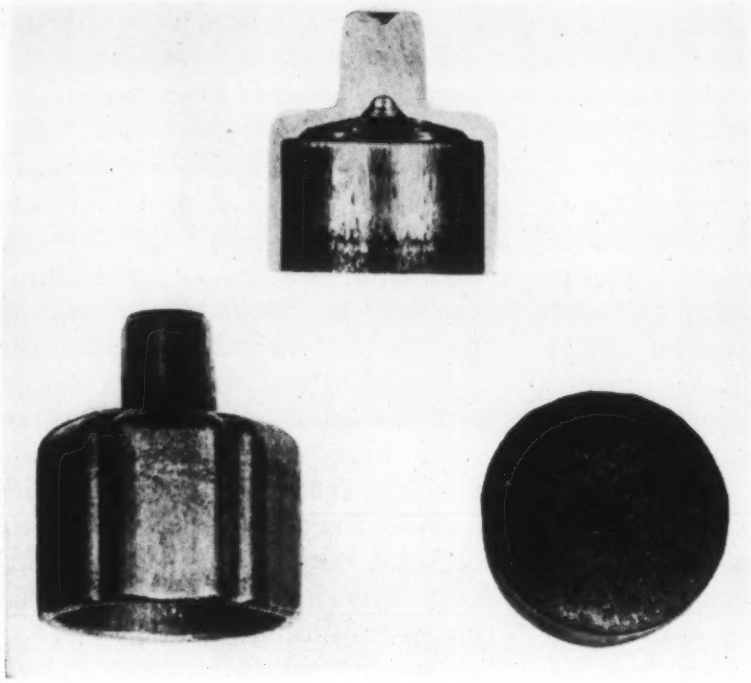
On ferrous surfaces the coatings consist of manganese and iron phosphate crystals. Even after the coatings have been worn off, the small pits etched in the bearing surface act as oil reservoirs. Since they are saturated with oil, the coatings provide considerable corrosion resistance and are quite beneficial for parts to be stored.

In addition to their ability to retain lubricants, phosphate coatings also help prevent the welding of ferrous surfaces under load. In addition to forming an antiflux layer, the phosphate coating process removes some ferrite (the constituent in iron which welds most readily) from the metal surface.

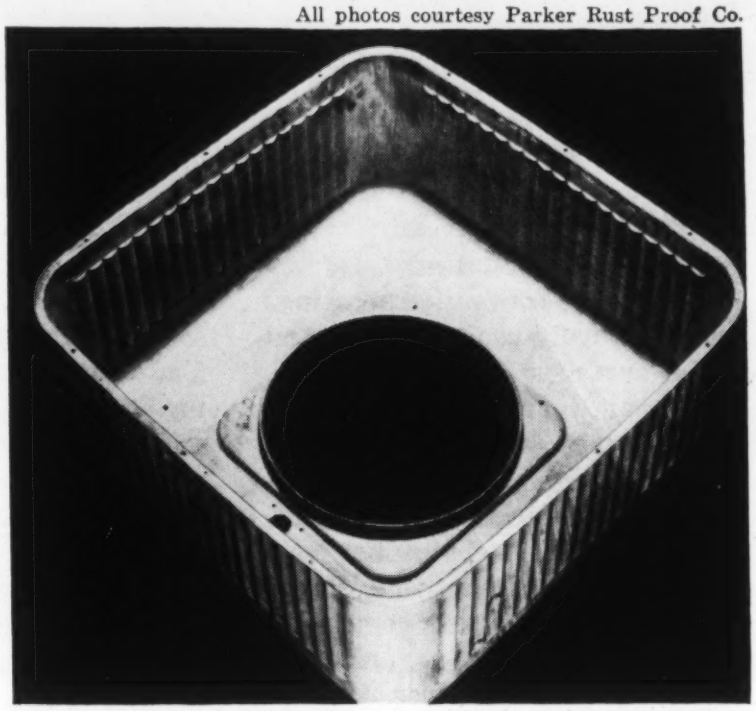
The acid reaction of the treatment bath also removes burrs, wire edges and other irregularities occurring on the bearing sur-

Phosphate coatings aid cold forming

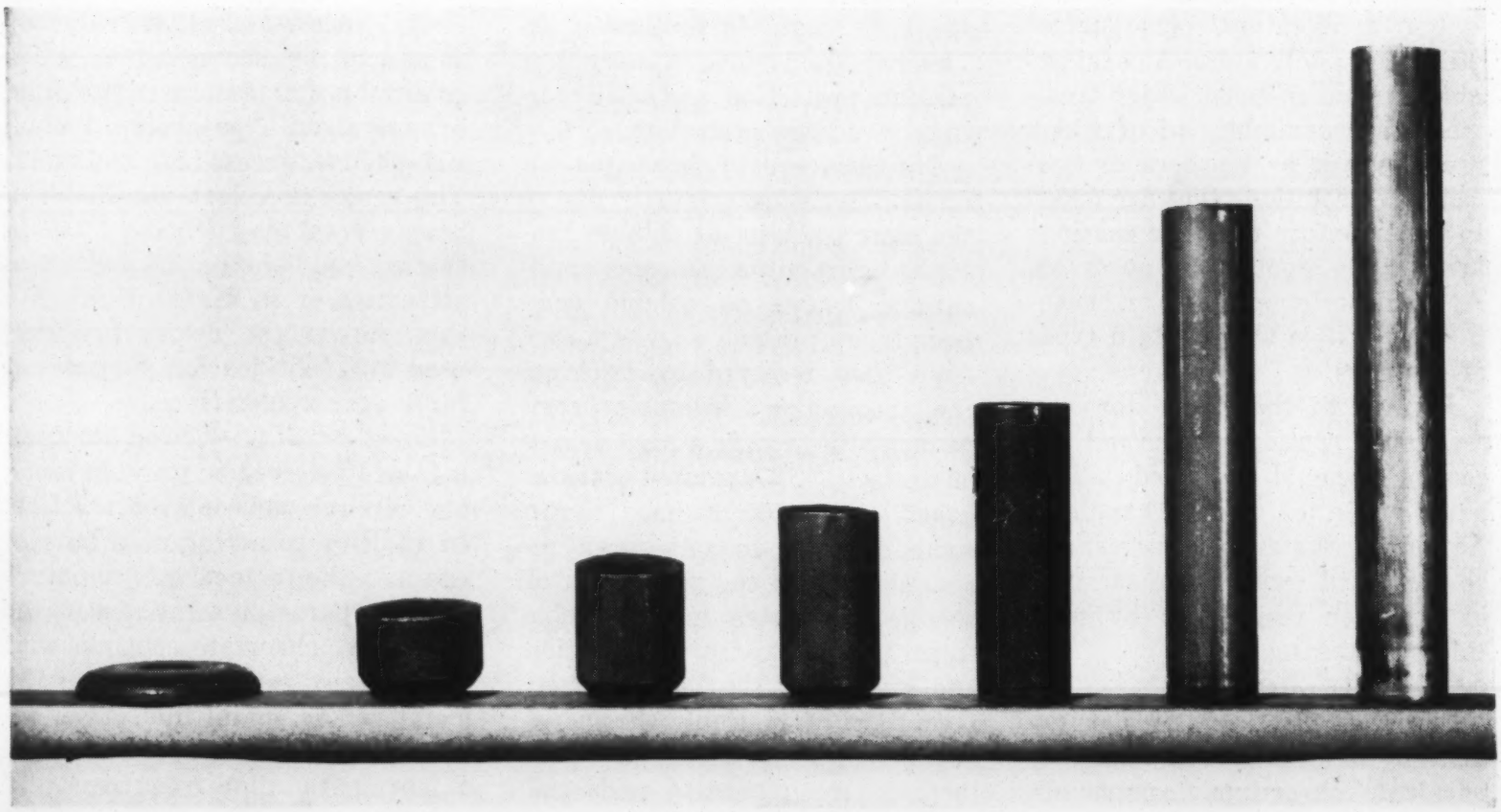
All photos courtesy Parker Rust Proof Co.



Steel cup *is extruded in one operation after application of phosphate treatment.*



Zinc coated ***washing*** *machine part is given phosphate coating to facilitate drawing and promote paint bonding.*



Aluminum cylinder *made in six stages. Phosphate coating permits deeper draws, lengthens die life.*

face. The coatings are quite smooth and their mild polishing action is conducive to rapid and safe break-in.

Because of dimensional build-up, special care must be given to close tolerance parts. Growths of only 0.1 to 0.15 mil can be obtained by adjusting bath acidity and controlling the use of metal activating agents to produce a very fine and dense coating. Burnishing or lapping may be used for thickness control if the required tolerances are less than 0.1 mil. Although the outer surface of the coating is removed by such treatments, the amount of phos-

phate remaining on the surface is sufficient for protection.

Phosphate coatings are used in a number of automobile and engine applications to improve wear resistance. Typical of the parts that have been coated are piston rings, valve lifters and guides, camshafts, rocker arms, cylinder liners, universal joints, gear shift forks, differential gears and automatic transmission parts.

Chromate Coatings

Chromate conversion coatings are principally used to 1) protect metal surfaces against corrosion, 2) enhance surface appearance, and 3) serve as a base for organic finishes. They were originally developed to protect lead; however, in recent years their use has been extended to cadmium, zinc, aluminum, magnesium and copper alloys. The coatings are also occasionally used on silver, tin and ferrous alloys.

All of the chromate baths use chromic acid or one of its soluble salts and contain hexavalent chromium, accelerators, plus surface etchants or activators. A considerable number of proprietary treatments are available, all of which are supplied as powders or concentrated solutions that are added to water before use. The coatings are usually applied by spraying. Application by spraying or brushing is possible with certain types of coatings.

Because of their poor abrasion resistance, especially when wet, the coatings should be dried before being subjected to shop handling. Abrasion resistance, however, can be increased (with some sacrifice in corrosion resistance) by suitable heat treatment.

General properties

Chromate coatings consist essentially of insoluble, nonmetallic, trivalent chromium compounds and some soluble hexavalent chromium compounds. Unlike most phosphate coatings, chromate films are noncrystalline and amorphous.

Corrosion resistance—The protection afforded by chromate coatings is twofold. First, the nonporous nature of the film (after it has dried) acts as a barrier to prevent moisture from reaching the basis metal. Second, if the coating should be scratched, the soluble portion of the chromate film continues to exert an inhibiting action (sometimes called a self-healing or bleeding action) to retard corrosion of the basis metal.

The protective value of a chromate coating depends on a number of factors such as: type, thickness and hardness of the coating, surface characteristics, purity and thickness of the basis metal, method of application and service environment. For example, heavy olive drab coatings provide the best corrosion protection, iridescent yellow coatings give medium protection, and clear coatings give least protection.

The resistance of chromate coatings to moisture is partly due to the slow leaching of soluble hexavalent chromium. In some applications where no soluble compounds are present, or where they have been removed by leaching, the remaining insoluble compounds still provide a high degree of protection. Unpainted coatings baked above 200 F have shown some decrease in salt spray resistance due to the conversion of soluble chromates into insoluble form together with dehydration and cracking of the film. However, formation of insoluble chromates during baking is accompanied by increased resistance to acids and alkalis.

Color—Chromate coatings are generally less than 0.02 mil in thickness. Two types of thin bright films can be obtained: yellow iridescent and clear. It is believed that the yellow color is caused by hexavalent chromium. The clear coatings are obtained by bleaching hexavalent chromium from the original film with acids, alkalis or water. The remaining coating is believed to consist mainly of chromium oxide plus water of hydration. Clear coatings are not as durable as yellow or olive drab coatings and, consequently, are often protected with a clear lacquer. Because of their brilliant appearance, clear coatings have been used to simulate nickel-chromium electroplates.

Heavier, matte coatings in yellow, bronze, black, brown and olive drab (the most durable and protective) colors can also be obtained. Because of their absorptivity, yellow and olive drab coatings can be converted to other colors by immersion in acidified organic dyes. These colors include red, orange, green, blue and violet. The range of colors obtainable is not as great as with dyed anodic coatings and the colors are not as attractive or as fast to light. For this reason the colors are only used for identification purposes or for indoor applications.

Paint bonding—Chromate coatings are believed to provide bonding through molecular attraction. In addition to acting as a barrier against the attack of moisture through pores or scratches in the paint film, chromate coatings also prevent any reaction between the metal and the paint film. Also, because of its nonporous structure, a chromate film requires less paint for a given coverage (for a gloss finish) than a phosphate coating.

Welding and soldering—Chromate surfaces can be spot or seam welded. High currents, however, may be required for the heavier weight coatings, and in some cases the coating may have to be mechanically removed in the area of the weld. In general, soldering

can be accomplished with normal acid fluxes, but the chromate film may have to be removed in some applications.

Coatings for zinc, cadmium

Under ordinary conditions zinc has a tendency to develop a grayish color which detracts from its appearance. Also, when exposed to moisture, zinc may develop a bulky film of white corrosion products which can hinder operation and produce a rapid loss of metal. In general, the same holds true for cadmium surfaces. Chromate coatings are particularly effective in inhibiting this type of corrosion and for this reason are more widely applied to zinc and cadmium than to other metals.

Zinc electroplates as thin as 0.02 mil have been successfully chromate-coated, although a minimum plate of 0.2 mil is desirable. Below 0.2 mil the effectiveness of the chromate coating is decreased, apparently because of an increase in plate porosity. Though chromate coatings can be applied to any thickness of zinc plate, the optimum thickness for maximum protection from white corrosion products is about 0.7 mil.

Most protective chromate coatings for hot dip galvanized surfaces are effective primarily on relatively pure zinc. However, proprietary baths are available for treating burnt areas, or for treating coatings with a high iron, low zinc content. On these surfaces the chromate coating is dull brown in color as contrasted to its highly iridescent yellow color on pure zinc.

The majority of chromate treatments for zinc and cadmium electroplates require the following sequence of operations: 1) electroplate (0.2 to 0.3 mil min), 2) cold or warm rinse, 3) immerse in chromate bath for approximately 5 to 60 sec at 60 to 120 F and pH of 0 to 3.5, 4) rinse, 5) bleach (optional depending on color desired and process used), 6) warm or cold rinse (optional), 7) hot rinse at 140 to 160 F, and 8) air dry.

In general, the light iridescent coatings are produced in a pH range of 0 to 1.5 and the darker or heavier coatings in a pH range of 1.5 to 3.5. The bleaching step listed above is designed to remove soluble chromates from the coating where a clear or light iridescent effect is desired. The corrosion resistance of bleached coatings is not as good as that of coatings left intact. In typical salt spray tests on zinc plated steel, only 24 to 100 hr of exposure were required to produce white corrosion products on a specimen coated with a bright chromate treatment, as compared to 100 to 500 hr for an olive drab-coated specimen.

Coatings for aluminum

Chromate conversion coatings on aluminum have replaced anodizing in many applications where good corrosion resistance, a very flexible coating, a good paint bond, low electrical resistance or low cost is required. However, the abrasion resistance and dielectric properties of chromate coatings are not as good as those of anodic coatings.

Chromate coatings are much thinner (about 0.01 mil) than anodic coatings, and color varies from clear to dark as thickness increases. The amount of aluminum that enters into the reaction is so slight that the dimensional stability of closely machined surfaces is not affected. For a given thickness, chromate coatings provide better corrosion protection than anodic coatings. Chromate treatments have proved beneficial on all aluminum alloys and forms, including work hardenable and heat treatable alloys in rolled, drawn, extruded and cast forms.

Salt spray resistance of coated alloys varies in the same order as the resistance of the uncoated alloys and is inversely proportional to copper content. Yellow-coated alloys with a copper content of 5 to 10% have shown first signs of breakdown after 50 to 200 hr. Alloys with a 3.5 to 5% copper content have withstood 200 to 300 hr, and alloys with negligible copper have shown first signs of white corrosion in 250 to 1000 hr. In general, the salt spray resistance provided by clear coatings is less than that given given by yellow coatings. Chromate coatings also increase the resistance of aluminum to mild alkalis and acids.

Compared to anodic coatings, chromate coatings have very low resistance to direct and alternating currents. Resistance values vary from 2500 to 50,000 microhms, depending upon coating composition and operating conditions. In general, the coatings can be classed as conductors rather than dielectrics. Thus, protection can be provided for chassis, shields, mounting brackets, wave guides, connector plugs, etc., without interfering with electrical characteristics or ground connections. Electrical resistance of chromated surfaces is somewhat higher than that of clean aluminum; however, resistance values are stable and compare favorably with those of surfaces that have become oxidized.

Chromated aluminum surfaces also have an advantage in that they can be welded. During arc welding, welds on chromated alloys have shown excellent penetration and freedom from contamination. It is also possible to weld chromated sheets right from stock without preliminary cleaning.

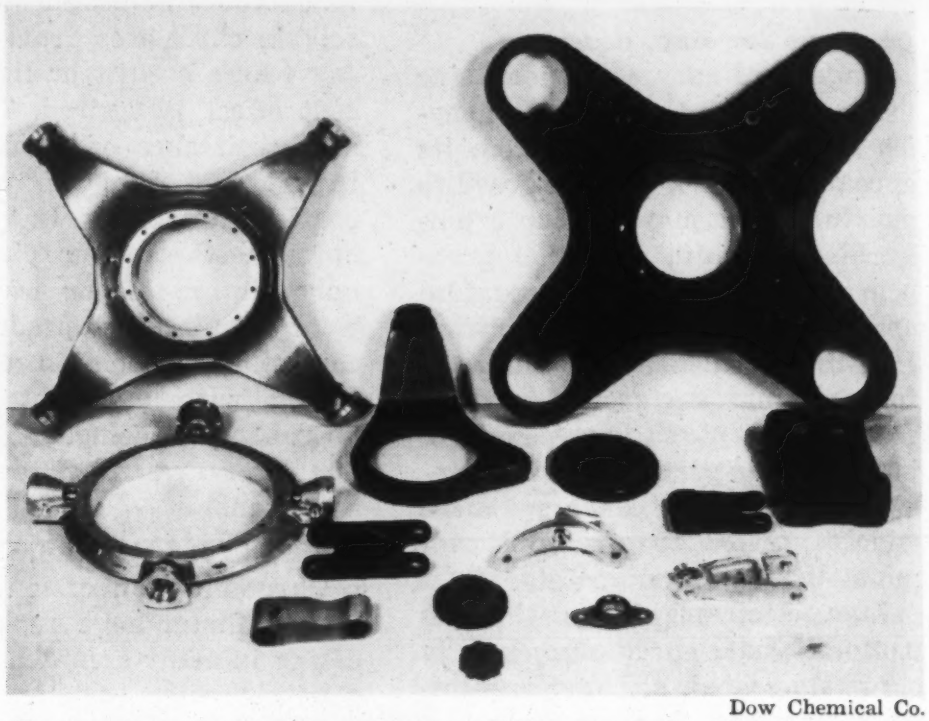
Chromate coatings for aluminum can be applied by spraying, immersion, flow coating or brushing. Brush or flow coat application is used on assemblies too large for tank immersion, or for touching up small areas. A typical immersion solution has a pH of 1.5 to 1.7 and a temperature of 75 to 95 F. Optimum time of immersion for a clear treatment is 10 to 30 sec; for yellow coatings about 2 min. On a few alloys, additional protection can be obtained by extending the time of immersion up to 3 to 8 min. Typical spraying solutions are operated at a pH of 1.8 to 2.0 and require about 10 to 30 sec for application.

Chromating has replaced anodizing on such typical aluminum aircraft parts as skins, structural members, hydraulic lines and

Chromate coatings fight corrosion

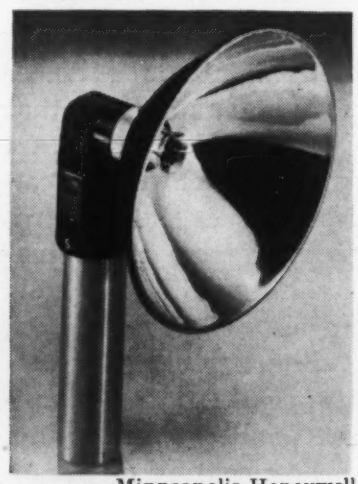
Parker Rust Proof Co.

Aluminum casting, *photographed after 24-hr salt spray test, demonstrates comparative* **corrosion resistance of untreated (upper half)** *and chromate treated (lower half) surfaces.*



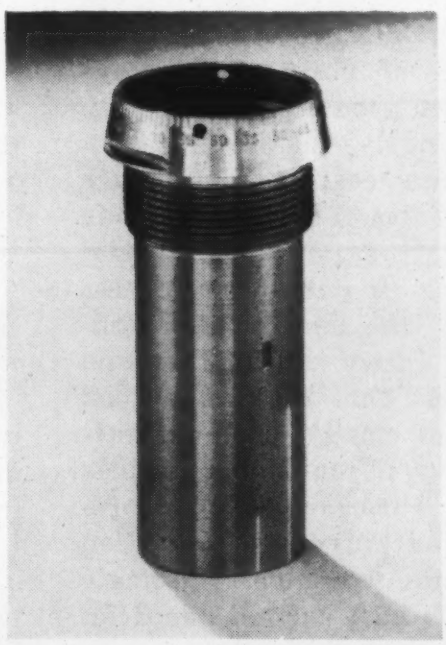
Dow Chemical Co.

Magnesium helicopter parts *exhibit no appreciable change in dimensions when given Dow No. 7 dichromate treatment.*



Minneapolis-Honeywell Regulator Co.

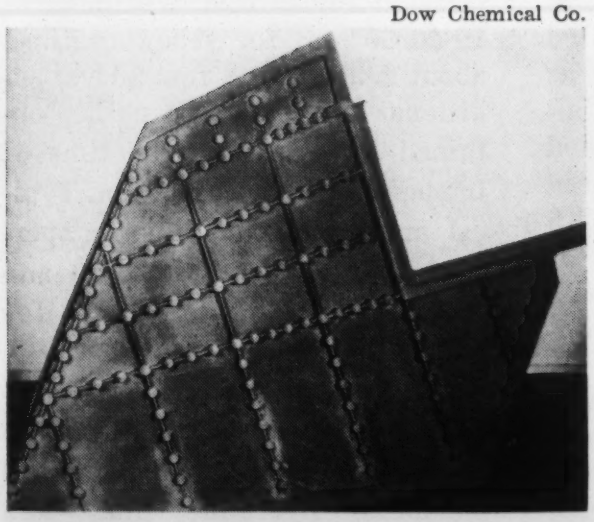
Flash Reflector *of aluminum is chromate treated to protect surface and retain original brightness.*



Allied Research Products, Inc.

Aluminum fuse part *(left) and bolt (right) are chromate coated for added corrosion protection.*

Dow Chemical Co.



Magnesium *thin-walled casting for* **Regulus missile** *is given Dow No. 1 chrome pickle for protection during shipment and storage.*

Allied Research Products, Inc.

Galvanized surfaces *are chromate coated for increased corrosion resistance.*

Gries Reproducer Corp.

Zinc die castings *are protected against formation of heavy corrosion products by chromate coating (Cronak process).*

castings. Other applications include aluminum boats and truck bodies, outboard motors and fishing rod handles.

Coatings for magnesium

A considerable number of proprietary chromate conversion coatings are available for magnesium and its alloys. Principal among these are Dow No. 1 (chrome pickle), Dow No. 7 (dichromate), Dow No. 10 (sealed chrome pickle) and Iridite No. 15.

Dow No. 1 chrome pickle is probably the most widely used general purpose treatment. The coating can be applied to practically all magnesium alloys, provides a good paint base, and is frequently used for temporary protection during shipment and storage (the coating is applied to virtually all sand and permanent mold castings shipped to users).

Dow No. 1 coatings are most frequently applied by dipping. About five steps (alkaline cleaning, cold rinsing, chrome pickling, and cold and hot rinsing) are required. Total processing time is about 6 min. For greater corrosion protection, the pores of the coating can be rendered impermeable by "sealing" in a boiling dichromate solution (Dow No. 10).

Brushing is sometimes used for coating large parts and for touching up untreated or damaged areas. Since the etching action of the chrome pickle removes about 0.6 mil of metal per surface (1.2 mil per dia), the treatment is not recommended for machined surfaces unless tolerances permit or proper allowances have been made. The treatment can be used on parts containing steel or brass inserts; however, polished steel surfaces should be protected with a removable film or a stop-off lacquer.

The color, luster and etch produced by this treatment vary with alloy composition, heat treatment of the basis metal, and age of the solution. The most desirable paint base is an iridescent, matte gray to yellow-red coating, obtainable in fresh solutions. Fresh solutions are mandatory for M1A and ZK60A alloys, since otherwise they tend to acquire bright, brassy coatings which promote poor paint adhesion.

Dow No. 7 dichromate treatment provides excellent corrosion protection and good paint-base characteristics to all magnesium alloys except M1A and the new rare earth alloys. Color of the coatings varies from light to dark brown, depending on the alloy. The coatings can be applied after machining, since no appreciable dimensional changes are produced during treatment.

Approximately 45 min are required for the treatment, which consists of : 1) alkaline cleaning, 2) cold rinse, 3) hydrofluoric acid immersion, 4) cold rinse, 5) dichromate immersion, and 6) cold and hot rinses. Castings and other parts containing bearings, studs and inserts of brass, bronze, cadmium plate and steel may be treated. Aluminum, however, is rapidly attacked by hydrofluoric acid, and parts containing aluminum inserts or rivets should be given an acid fluoride dip instead.

Dow No. 10 treatment is essentially a combination of the chrome pickle and dichromate boil, No. 1 and No. 7. It is most commonly used for wrought products but can be applied to castings. The coating possesses the varying, matte gray to yellow-red iridescent color of the chrome pickle, plus the brown of the dichromate treatment. As with the No. 1 treatment, the amount of metal removed by etching must be considered.

Iridite No. 15 treatment is a recently developed proprietary treatment for magnesium surfaces. Its corrosion protection and paint-base qualities are roughly equivalent to those of Dow No. 7. A light to dark brown coating is formed in from 15 sec to 2 min. No fuming occurs during processing, and the coating can be applied by brushing or swabbing.

Coatings for copper

Chromate coatings for copper alloys have achieved wide popularity because of their ability to provide a bright, tarnish-free finish, to eliminate mechanical buffing, and to prepare a bright surface for chromium plating. Chromate treatments also have an advantage in that they eliminate the hazard of toxic fumes encountered with conventional nitric, sulfuric and hydrochloric acid brightening solutions.

Corrosion resistance of the coatings is fair. The time required to produce green corrosion products on coated copper panels during salt spray tests has been measured at 24 and 50 hr for bright and heavy coated panels, respectively, as compared to less than 24 hr for untreated panels. Similarly, corrosion products on brass panels were produced after 100 and 150 hr for bright and heavy coated panels, respectively, as compared to less than 24 hr for untreated panels.

The protective and decorative value of the coating varies with its thickness, the type of treatment and the particular copper alloy. The corrosion resistance of chromate coated brass parts, for example, increases as the zinc content increases. Mirror-bright coatings can be obtained on fine grained and homogeneous wrought alloys. Surfaces on coarse grained alloys are bright, but somewhat less smooth in appearance and texture. Heterogeneous alloys such as leaded and beta brass and phosphor bronze do not dissolve uniformly during treatment and consequently do not brighten as well as the homogeneous alloys.

The coatings do not flake off during cold forming or bending and do not affect the dimensions of close tolerance parts. They can be spot or shielded-arc welded and provide unusually low contact resistance. The specific electrical resistance at 100 psi ranges from 500 to 1900 microhms per sq in., depending on film thickness.

A typical chromate treatment for copper and brass consists of: 1) alkali cleaning, 2) water rinsing, 3) immersion in chromate bath for 10 to 30 sec at temperatures to 140 F, 4) rinsing in cold and warm water, and 5) drying.

Anodized Coatings

Anodizing is an electrochemical method in which the surface of a metal is converted to an oxide when the metal is made the anode in certain electrolytes. The physical and mechanical properties of oxide coatings are often quite different from those of the basis metal. The process is used principally to improve the resistance of metals to corrosion and abrasion and to enhance surface appearance. It has proved extremely popular for the protection and decoration of aluminum and magnesium alloys.

Coatings for aluminum

By proper control of the electrolyte and operating conditions, anodic coatings for aluminum can be formed with predictable thickness and density. The degree of porosity determines the absorption characteristics of the coating and also affects its resistance to abrasion. Because of their density, coatings with a relatively small number of small diameter pores possess high abrasion resistance and will support high loads.

Types of treatments—The electrolytes most commonly used for anodizing aluminum are sulfuric, chromic and oxalic acids, and mixtures of sulfuric and oxalic acids.

Sulfuric acid anodizing with direct current is the most popular anodizing process. These coatings vary in appearance from transparent to translucent, depending on the alloy used. Coatings on pure aluminum are relatively hard and transparent, and have a glaze-like appearance. A standard uncolored coating is produced in 30 min in a 15 to 18% sulfuric acid bath operated at 70 F.

Chromic acid anodizing is generally more expensive, produces thinner coatings, and requires higher voltages than the sulfuric acid process. Because of the presence of chromium compounds in the pores, these coatings provide high resistance to corrosion. The thin coatings have low abrasion resistance, but high flexibility. The chromic acid process is critical with respect to alloy composition, and it is difficult to coat some alloys, particularly casting alloys. The coatings have an opaque, slightly iridescent appearance.

Oxalic acid anodizing produces coatings that are essentially transparent. Film color varies from light yellow to bronze. Coatings are dense and have low color absorption capacity, but possess high abrasion resistance.

Mixed electrolytes of sulfuric and oxalic acids are sometimes used to obtain even denser coatings with greater abrasion resistance. Anodic coatings have also been obtained in electrolytes of oxalic, sulfamic, phosphoric and boric acids; however, these treat-

ments have not achieved wide usage as yet.

Coloring—Organic coloring dyes and pigments can be absorbed in the pores of anodized coatings to produce a wide variety of decorative effects. In such applications the luster of the underlying metal imparts an attractive metallic sheen to the surface. By using different alloys (such as 5357 and 6063 aluminum-magnesium alloys) and colorants, anodized coatings can be made to simulate such metals as gold, copper, bronze or brass. For maximum luster, surfaces are buffed and brightened before anodizing.

The insolubility of some constituents in aluminum alloys is often used to enhance the appearance of the coating. During anodic oxidation the silicon particles in aluminum-silicon alloys remain unchanged. The attractive finish produced in gray architectural slabs is an example of this effect.

In many cases constituents will oxidize to color the coating. The brown opaque appearance of alloys containing manganese is due to the formation of manganese dioxide during anodizing. The yellowish appearance of alloys containing chromium constituents is also caused by oxidation.

In general, the more continuous and transparent coatings are produced with the purer grades of aluminum. Super purity aluminum produces the most transparent oxide coating. Alloys such as 5357 and 6063 produce essentially transparent coatings with considerable metallic luster.

Sealing—Most anodic coatings must be sealed to close the pores and prevent absorption. Sealing is usually accomplished by immersion in hot water or wet steam; however, water solutions of chromate, silicates and phosphates are also used. Oil, wax or graphite impregnants are sometimes used for special applications.

Since organic dyes are soluble in water, colored anodic coatings cannot be sealed by conventional hot water methods. Consequently, acetates of nickel or cobalt are generally used to seal dyed coatings. The colloidal hydroxides produced by hydrolysis of the hot solution precipitate and close the pores.

Hard coatings—Hard anodized coatings, produced by various proprietary techniques, are particularly valuable where high resistance to abrasion, erosion and corrosion, combined with light weight, is required. Because of their greater thickness (1 to 5 mils) and density, these coatings can carry greater loads, and have higher resistance to scratching and abrasion than the conventional anodic coatings (0.1 to 2.0 mils).

Principal among the hard coatings for aluminum are the Alumilite 225 and 226 coatings for wrought alloys, Alumilite 725 and 726 coatings for cast alloys, the Martin Hard Coating (MHC), and the Sanford and Hardaz processes. Alumilite 225 and 226 coatings are for wrought alloys; the 725 and 726 coatings are for cast alloys. In general, an allowance of 50% of coating thickness should be made for surface growth.

Hard anodic coatings can be applied to all aluminum alloys, but certain alloys respond better to anodizing than others. Care must be taken in anodizing casting alloys, as they usually contain appreciable amounts of silicon; alloys with more than 7% silicon do not respond satisfactorily. Also, alloys with high copper or silicon content will not produce dense coatings of uniform thickness. Coatings can be formed on such wrought alloys as 2011, 2014, 2017 and 2024, but operating conditions are critical and the coatings are not as resistant to abrasion as coatings formed on such alloys as 1100, 3003, 5052, 6061 and 7075. In general, coatings formed on castings are not as smooth as those obtained on wrought products.

It is difficult to measure the hardness of anodic coatings, but wear resistance data are available. It has been reported that after 50,000 cycles of testing on a Taber Abraser, a 2-mil MHC coating showed only about half as much wear as the surface of case hardened steel. In general, hard coatings have greater resistance to rubbing abrasion that to blast abrasion, and possess about twice as much resistance to grit blast abrasion as conventional anodized coatings of the same thickness.

Coatings for magnesium

Because of their susceptibility to galvanic corrosion and abrasive damage, magnesium surfaces are frequently protected with an anodic coating. A number of proprietary treatments are available that, in addition to inhibiting corrosion and abrasion, also enhance decorative appeal and provide a paint base.

Dow No. 9 galvanic anodize treatment is applicable to all magnesium alloys, and is especially suitable for the M1A alloy or any other non-aluminum-containing alloys that cannot be given the No. 7 dichromate treatment. The coating is black in color and since no dimensional changes occur during processing, is normally applied after machining.

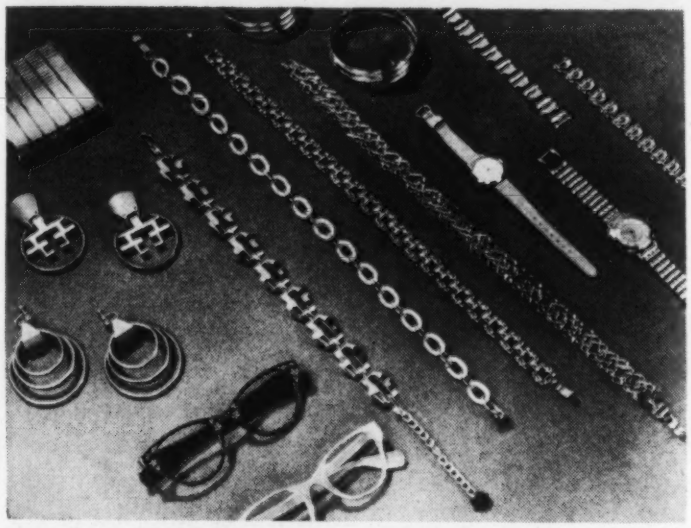
Prior to treatment, parts are given a brief hydrofluoric acid dip, then are electrically connected with the tank or cathode plates. The bath consists of a hot (120 to 140 F) dichromate-sulfate solution, and treatment lasts from 10 to 30 min. About 70 amp-min per sq ft of anode area are usually required to obtain a uniform coating.

Dow No. 12 caustic anodize is a specialty treatment combining decorative appeal with moderate corrosion and abrasion resistance. The coatings vary in color from light gray to light tan and, unlike most of the other anodic coatings for magnesium, they can be dyed.

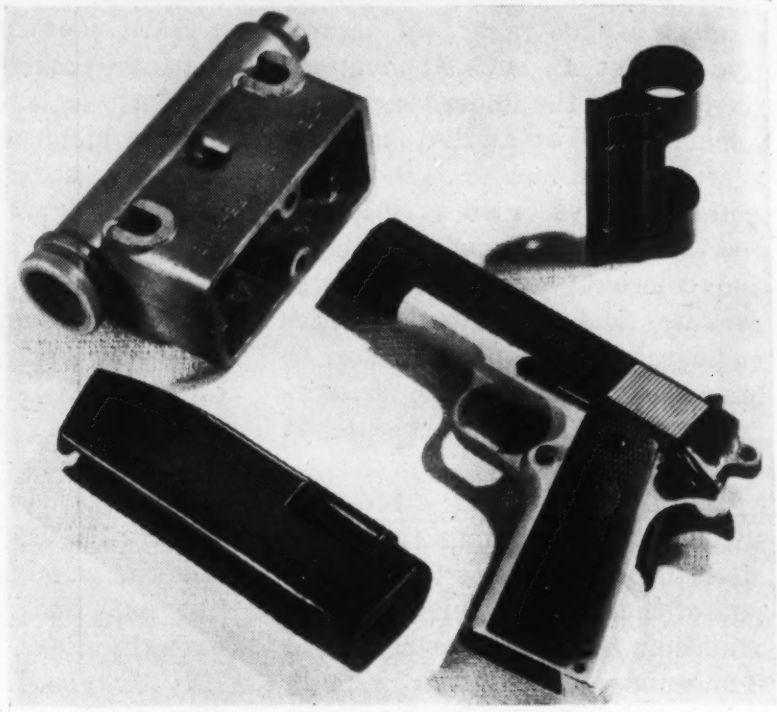
Although the treatment is applicable to all magnesium alloys, die castings should be pickled in a strong phosphoric acid solution before anodizing. Temperature of the bath is about 165 to 175 F, and treatment requires from 15 to 25 min. If coatings are to be

Anodic coatings: protection plus eye-appeal

All photos courtesy Aluminum Co. of America except as noted

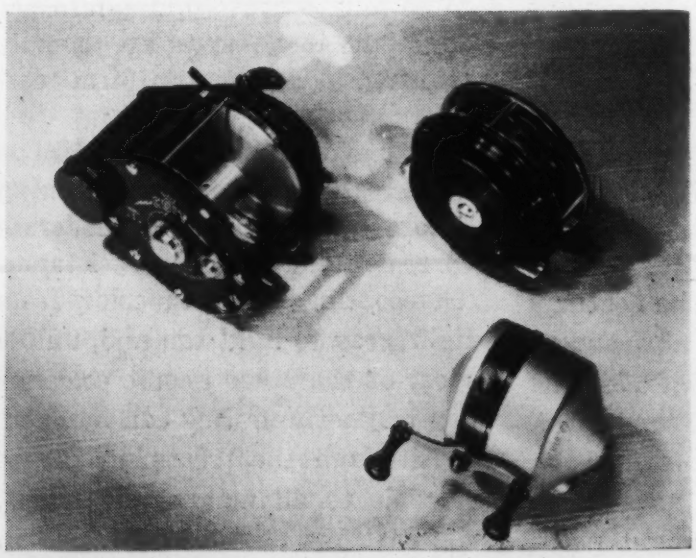


Aluminum jewelry *items are given colored anodic coating for added decorative appeal.*



Aluminum hydraulic brake cylinder *(upper left) is provided with anodic coating for corrosion and wear protection. Black anodic coating on rifle 'scope part (upper right) and other gun parts provides low reflectivity.*

Aluminum camera body *is given clear anodic coating after satin finishing.*



Aluminum fishing reel *parts are color anodized to give attractive appearance and corrosion protection.*

Aluminum giftware *is anodized afer buffing.*

painted, anodizing should be followed by a 15-min dip in a sodium fluosilicate-sodium dichromate sealing solution.

Dow No. 14 anodizing process is also applicable to all magnesium alloys, and is especially useful in covering surface defects such as flow marks in die castings. The electrolyte consists essentially of a borate-silicate solution with additives of sodium hydroxide and phenol. Initially, a minimal voltage is applied; as film thickness and electrical resistance increase, voltage is built up to maintain current density at 10 to 15 amp per sq ft.

The coating is light gray to white in color and should be waxed to prevent smudging. It cannot be dyed; however, it can be painted after sealing in a sodium dichromate - sodium acid fluoride bath.

Dow No. 17 anodizing process produces the most abrasion resistant coating and the best paint-base coating of all Dow chemical processes. Furthermore, the process requires less control of processing variables than most other treatments.

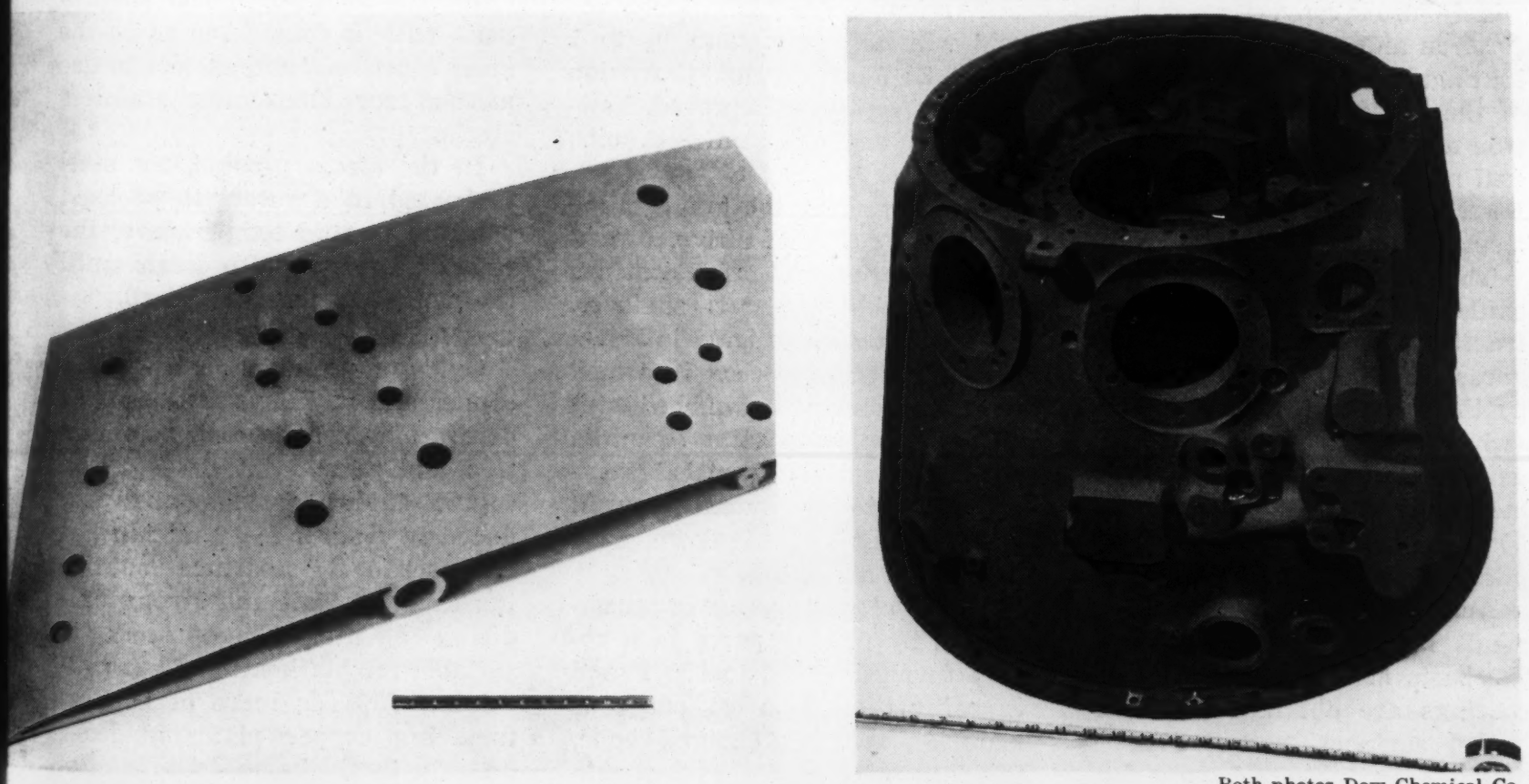
Two types of coatings may be obtained. A thin, light green coating is produced at comparatively low voltages, and is quite popular for flexible sheet forms. A dark green coating is produced at higher voltages and is recommended for castings and extrusions. The latter coating has a tendency to spall; however, this condition can be alleviated by using special paints. The dimensional increases produced by the light and dark green coatings are about 0.2 and 1.0 mil, respectively —roughly two-thirds of the coating thickness.

Coatings can be applied with alternating or direct current. Direct current produces coatings that are smoother and somewhat more abrasion resistant than coatings applied by alternating current. Direct current also requires 30% less time for processing at a given current density.

Steel or brass inserts should be placed after anodizing (otherwise, since they do not polarize in the anodizing bath, they would produce pitting). If this is not possible, they should be insulated from the electrolyte by masking with a baked phenolic coating or suitable plug. In general, small aluminum attachments, such as rivets, can be anodized.

The HAE treatment has demonstrated its ability to improve the abrasion, corrosion and heat resistance of magnesium surfaces in a number of applications. Unpainted, sealed panels have exhibited only a few pinholes after 200 hr of salt spray testing.

The HAE coatings possess good resistance to thermal shock, and have been reported to withstand temperatures to 2500 F. Hardness is about 7 to 8 on the Moh scale. HAE coatings are quite brittle and are vulnerable to chipping,



Both photos Dow Chemical Co.

Magnesium missile-fin *casting (left) and reciprocating engine casting (right) are anodized by Dow No. 17 process.*

cracking and spalling. Discontinuities can promote severe pitting, since the coating contains inhibiting chromate and is quite cathodic to the basis metal. For this reason, HAE coatings are preferably used on rigid, heavy sections in which flexure, and consequent coating damage, is less liable to occur. Also, since the coatings are liable to crack during riveting and bolting operations, it is preferable to apply them after all fabrication and assembly operations have been completed.

The coating is about 1 mil thick and produces an increase in surface dimensions of about 80% of film thickness. It is applied in 60 to 90 min at 75 to 85 F in an electrolyte made up of potassium and aluminum hydroxides, trisodium phosphate, potassium fluoride, potassium manganate and water.

Oxide and Other Coatings

In addition to the phosphate, chromate and anodic coatings described above, other chemical conversion coatings are available for iron, steel, zinc, cadmium, copper, aluminum and titanium surfaces. These coatings vary in composition and are usually produced by exposing the metal to hot, oxidizing solutions or gases. They are usually quite thin, often have a characteristic color, and are used primarily for decoration, for corrosion protection or as a paint base.

Coatings for iron, steel

Next to phosphate coatings, black oxide coatings are the most widely used conversion coatings for iron and steel surfaces. These coatings are composed essentially of the black ferro-ferric oxide of iron and can be produced by several methods; the hot (about 300 F) alkali-nitrate method is the most popular.

The chief advantages of black oxide coatings are: 1) their attractive appearance, 2) their abrasion and chipping resistance, 3) their low coefficient of friction (when oiled or waxed) and nongalling surface, 4) the small dimensional changes produced, and 5) their economy and ease of application.

Appearance of the coating depends largely on the surface of the basis metal. Attractive shiny coatings are obtained on highly buffed surfaces, and dull matte coatings are obtained on etched, brushed or sandblasted surfaces. Since the change in chemical structure is not accompanied by displacement of metal during processing, there is little change in surface dimensions. Thickness of the coating ranges from 0.04 to 0.2 mil, and the dimensional change produced is usually less than 0.01 mil.

The corrosion resistance provided by black oxide coatings is relatively low. Since carbon particles and other non-iron aggregates in the surface are not converted, the degree of protection depends somewhat upon the carbon content and impurities present in the metal. Thus, low carbon steels form more protective coatings than high carbon steels. Unprotected, black oxide coatings are not recommended for outdoor use and will only withstand ½ to 1 hr in 20% salt spray. Corrosion resistance can be improved, however, by impregnation with oils, lacquers or waxes.

In addition to the hot alkaline treatment described above, a number of other colored oxide coatings are available for steel surfaces.

The *browning process* is basically a rusting process in which the metal surface is swabbed with an acidic solution after cleaning. After drying, the surface is exposed to 100% humidity until rust forms, rubbed down, and then given an oil dip.

The *Carbonia process* is accomplished by placing parts in a rotary furnace at 600 to 650 F and exposing them to a carbonaceous material, such as charred bone, together with a thick Carbonia oil. After a 4-hr treatment the parts are removed and immersed in oil. The resulting coating is essentially a black oxide of iron and contains some carbon.

Various heat treatments can also be used to obtain an oxide coating on steel. These methods include oven heating, salt bath immersion and a steam process.

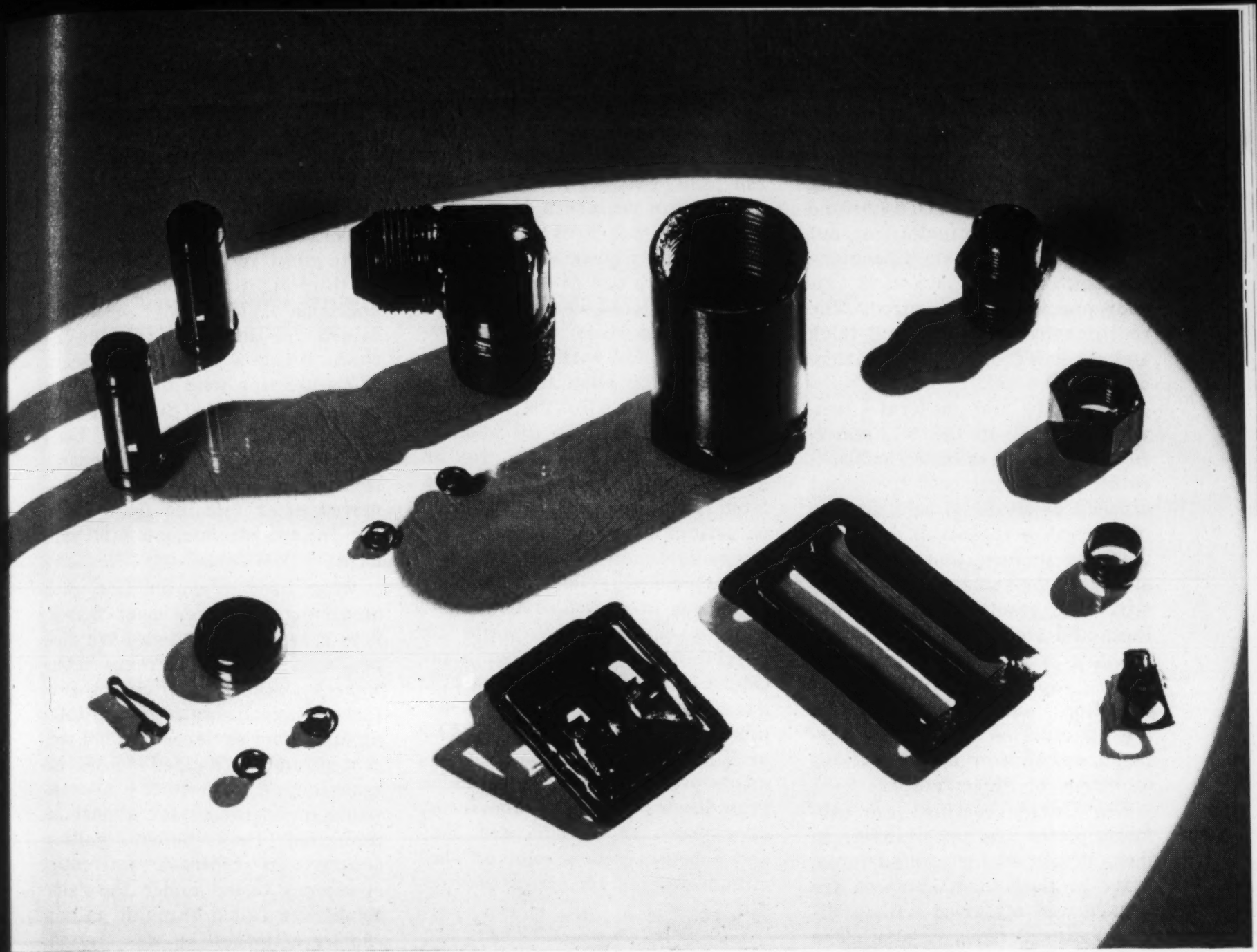
The *oven heating* method consists of oxidizing parts in an oven maintained at 600 to 700 F until they attain a bluish-black color. The shade of color depends on processing temperature and steel analysis, and it is usually difficult to maintain a uniform color.

Blue-black and black oxide coatings are obtained by *salt bath immersion.* Molten baths of a nitrate salt, alkali-nitrate mixture or dichromate are used. The dichromate bath is considered to be the most consistent and easiest to use method for blackening stainless steels.

In the *steam process,* the steel is heated in a retort to at least 600 F. At this temperature, the retort is purged with steam until the metal surface is oxidized.

Coatings for copper

Oxide conversion coatings for copper and its alloys are used for decoration, for corrosion protection and as a paint base. Black cupric oxide coatings are produced in from 2 to 10 min in hot (about 210 F) solutions containing caustic alkali and strong oxidizing agents. The process is suitable for blackening alloys containing 65% or more of copper, including copper plates at least 0.2 min in thickness. Alloys containing greater than 90% copper can be blackened directly after cleaning. Alloys containing 65 to 90% copper must be given an



Enthone, Inc.

Black oxide coating *on these parts produces little change in dimensions of threaded sections.*

additional activating treatment before blackening.

Attractive glossy finishes can be obtained by applying a coat of clear enamel or by oiling the surface after it has dried. Dull finishes are obtained by wiping the surface before it has dried or by applying a coat of wax.

Thickness of the black oxide coating ranges from 0.05 to 0.2 mil, the dimensional change being about 0.5 mil. The coatings are extremely adherent, will withstand considerable handling and wear, and can be used to 400 F without deterioration. Bare coatings will withstand 15 to 20 hr of salt spray testing before green salts appear. When protected with a hard wax or oil, they will withstand over 200 hr of salt spray before breakdown.

A black coating on copper can also be produced by immersion in a potassium sulfide solution for 5 to 10 sec at 100 F. A considerable number of colored finishes other than black are also available for copper and brass. (For comprehensive details on these finishes see "Maintenance, Cleaning, Finishing, and Coloring of Copper, Brass and Bronze," published by the Copper & Brass Research Assn.). Briefly, these finishes are:

Royal copper on copper — Obtained by immersion for 20 sec in a molten solution of potassium nitrate.

Brown on yellow brass — Obtained by 1-min immersion at 70 F in a solution of sodium bichromate and nitric and hydrochloric acids.

Gold on yellow brass—Same as above except for addition of sulfuric acid to solution.

Blue-black on yellow brass—Immersion for 10 sec at 180 to 200 F in solution of copper carbonate and ammonium hydroxide.

Light green on yellow brass—Immersion for 40 to 60 min in cold solution of sodium bichromate and phosphoric acid.

Steel gray on yellow brass—Immersion for 5 to 10 sec at room temperature in solution of arsenic trioxide and hydrochloric and sulfuric acids.

Statuary bronze on yellow brass—Immersion for 10 sec at 180 to 200 F in copper carbonate and ammonium carbonate solution, followed by dipping in dilute sulfuric acid solution.

Coatings for zinc, cadmium

Proprietary oxide coatings are also available for blackening electroplated zinc, zinc sheet, galvanized coatings and zinc-base alloys.

The coatings are primarily intended for decorative purposes and to serve as a paint base, and will withstand normal handling and wear. They can withstand exposure to mild atmospheres, but should be given a supplementary wax, oil or lacquer finish if outdoor protection is required. The coatings are 0.04 to 0.1 mil thick and produce a dimensional change of about 0.5 mil.

Both cold and moderate temperature (150 to 180 F) immersion baths are available for blackening. A typical cold treatment consists of cleaning, acid dipping to neutralize the alkali and activate the surface, and blackening at room temperature for 10 to 20 min. The resulting coatings are inert and stable at temperatures as high as 350 F. Gloss of the coating depends on initial surface condition: shiny black coatings are obtained on bright zinc surfaces, and dull or matte coatings on etched or dull surfaces.

Black oxide coatings for cadmium plates are quite similar to those developed for zinc surfaces. Prior to blackening, surfaces are cleaned and activated with a dilute hydrochloric acid dip. The coating is applied at a temperature of from 120 to 140 F in 10 to 20 min.

Coatings for aluminum

In addition to the coatings already described, a considerable number of proprietary oxide coatings are available for the protection and decoration of aluminum surfaces. These coatings provide a fair degree of corrosion resistance, retain an attractive dyed finish, and serve as an excellent paint base.

Despite their similar surface structure, chemical oxide coatings are not as thick and do not provide as good abrasion and corrosion resistance as the best anodic coatings. The chief advantage of the chemical oxide coatings is that they can be applied easily and cheaply. Special processing equipment is not required and the bath is made up mainly of soda ash and potassium dichromate. Treatments require 5 to 20 min.

Most chemical oxide coatings can be dyed; however, the colors produced are not as light fast as those of colored anodic coatings. The natural color of the oxide coating varies with the process used and the alloy treated. For example, an Alrok 4 coating, which is formed in an alkaline chromate solution, has a gray or greenish-gray color resulting from the presence of trivalent chromium compounds. After dichromate sealing the coating has a pronounced yellow-green tint. Other coatings, such as Alrok 731, have a characteristic white or grayish-white color. Aluminum-copper casting alloys, such as 112, have a dark gray or black color after application of an Alrok 712 or 714 coating. The same treatments produce a gray or greenish-gray color on aluminum-silicon alloys such as 43, 355 and 356, and a bright yellow color on aluminum-magnesium alloys such as 214.

Chemical oxide coatings are comparatively thin and their weight varies from 3½ to 8 mg per sq in., depending on processing variables and alloy used. Negative dimensional changes of the order of 0.1 mil are produced on wrought and casting alloys and need only be taken into account when very close tolerances are required.

Coatings for titanium

Conversion coatings for titanium are intended primarily to facilitate drawing and forming, and to increase wear resistance of the metal by mitigating its tendency to gall and seize. Satisfactory coatings, believed to consist of a potassium-titanium-fluoride complex, have been produced in low (80 F) and high (185 F) temperature fluoride - phosphate baths. The coatings are applied in 2 to 10 min, depending on bath composition, and their weight does not increase after a certain time limit has been reached.

These coatings have proved quite effective in the cold forming of titanium tubes and wire. Reductions of 65% have been obtained in the plug drawing of tubes using a suitable lubricant in conjunction with the high temperature coating. Similarly, reductions of 94% have been achieved in wire drawing operations. The coatings can be removed after forming by a short dip in a hydrofluoric-nitric acid bath.

When used in conjunction with an air oxidation treatment (800 F, 2 to 5 hr) the coatings have also produced a marked increase in the wear resistance of titanium surfaces. In reciprocating wear tests against steel surfaces at 2500 psi, coated and lubricated (SAE 30 machine oil) specimens are capable of operating for almost an unlimited time before galling occurs. In contrast, untreated specimens tested under the same conditions failed through galling shortly after testing was started. Similar improvements in the wear resistance of titanium surfaces has been reported after high speed rotary wear tests.

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Metal & Thermit Corp.
Mitchell-Bradford Chemical Co.
Mutual Chemical Div., Allied Chemical & Dye Corp.
Neilson Chemical Co.
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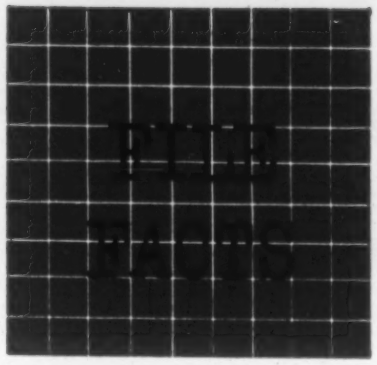


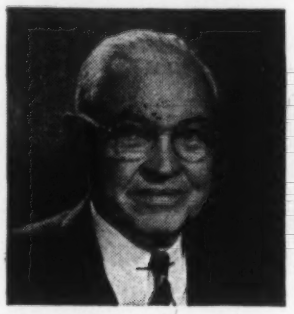
Cellulose Nitrate and Ethyl Cellulose

Type →		Cellulose Nitrate Sheet	Ethyl Cellulose Moldings		
			General Purpose	High Impact	
				A	B
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.35-1.40	1.10-1.16	1.10-1.16	1.10-1.16
Ther Cond, Btu/hr/sq ft/°F/ft	Cenco-Fitch	0.133	0.092-0.167	0.092-0.167	0.092-0.167
Coef of Ther Exp, per °F	D696	4.4-6.6 x 10^{-5}	5.5-11 x 10^{-5}	5.5-11 x 10^{-5}	5.5-11 x 10^{-5}
Refractive Index	D542	1.49-1.51	1.47	1.47	1.47
Transmittance (luminous), %	D791	89-92[a]	—	—	—
Haze, %	D672	2.0-4.0[a]	—	—	—
Water Absorption (24 hr), %	D570	1.0-2.0	1.2-2.0	0.8-2.0	1.0-2.0
Flammability (>0.050 in.), ipm	D635	[b]	0.5-1.5	0.5-1.5	0.5-1.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	1.9-2.2	0.5-3.5	1.0-3.0	1.0-3.0
Ten Str, 1000 psi	D638	7-8	3-7	4-6.5	3-5
Strain at Fracture, %	D638	40-50	—	—	—
Hardness (Rockwell)	D785	R95-115	R80-120	R80-90	R70-80
Impact Str (Izod notched), ft-lb/in	D758	5-7	1.7-6.0	3.5-6.0	4.0-7.0
Mod of Elast in Flex, 10^5 psi	D790	2.3-2.5	—	—	—
Flex Str, 1000 psi	D790	9-11[c]	4-10	6	4
Compr Str, 1000 psi	D695	22-35	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10-15 x 10^{10}	10^{12}-10^{14}	10^{12}-10^{14}	10^{12}-10^{14}
Dielec Str (short time), v/mil	D149	300-600	350-500	350-500	350-500
Dielec Const					
60 Cycles	D150	7.0-7.5	—	—	—
10^6 Cycles	D150	6.4	2.8-3.5	2.8-3.3	3.0-3.6
Dissipation Factor					
60 Cycles	D150	0.09-0.12	—	—	—
10^6 Cycles	D150	0.06-0.09	0.010-0.060	0.010-0.030	0.018-0.035
HEAT RESISTANCE					
Max Rec Svc Temp, F		120–140	—	—	—
Heat Dist Temp, F					
66 psi		200–220	—	—	—
264 psi		140–160	120–160	130–145	125–140
FABRICATING PROPERTIES					
Bulk Factor		—	1.8-2.4	1.8-2.4	1.8-2.4
Compression Molding					
Pressure, 1000 psi		—	0.5-5	0.5-5	0.5-5
Temperature, F		—	250-390	250-390	250-390
Injection Molding					
Pressure, 1000 psi		—	6-32	8-32	8-32
Temperature, F		—	350-500	350-500	350-500
Hot Forming Temperature, F		135-250	—	—	—
Extruding Temperature, F		180-200	300-450	350-450	350-450
Max Rec Service Temp, F		120-140	—	—	—
CHEMICAL RESISTANCE		Resistant to 30% sulfuric acid, carbon tetrachloride, 10% sodium chloride, 10% nitric acid, 10% hydrochloric acid, 5% acetic acid, 2% sodium tetrachloride, distilled water, aliphatic and aromatic hydrocarbons, and <1% sodium hydroxide. Soluble in ketones, esters, lower alcohols and glycol ethers. Attacked by concentrated sodium hydroxide, ethylene dichloride and 50% ethanol		Unaffected by 3 sulfuric, 5 acetic and 10% hydrochloric acids; 10% sodium hydroxide, 2% sodium carbonate and water. Slightly affected by 30 sulfuric and 10% nitric acids; and 10% ammonium hydroxide. Attacked by 95% ethyl alcohol, acetone, toluene and gasoline	
USES		Fountain pens, spectacle frames, drawing instruments, ping-pong and billiard balls		Radio housings, toothbrushes, pen and pencil barrels, tool handles	

[a] 1/8 in. sheet containing no color.
[b] Cellulose nitrate under 0.050 in. thick burns very rapidly (D568).
[c] No break; specimen failed by slipping through supports.

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

Bolts take greatest stress during wrenching

If a bolt doesn't fail when being wrenched up tight, it won't fail in service (assuming bolts and joint have been designed adequately for the loads).

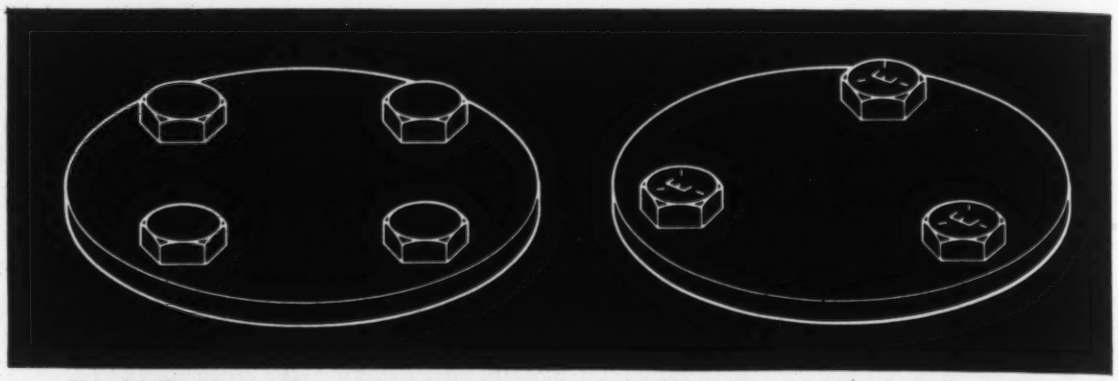
That's because two forces put stress on bolts (and cap screws) as they tighten: Tension due to bolt stretch; torsion due to friction. But only tension remains after wrenching. In a rigid joint, if this tension exceeds external forces, bolts will never experience any further strain, and will therefore not loosen or fail.

WHY SOME FAILURES?

Obviously, unusual unforeseen loads cause trouble. The instant they exceed residual tension, *they add* to the stress placed on the bolt and can cause *immediate* failure. Or they can cause loosening, leading to stress change, which in turn causes fatigue and failure. That's why you've got to torque bolts tight . . . and the tighter the better.

An exception: A flexible joint. With high cyclic loading, again loosening and fatigue cause trouble. Since you shouldn't tighten such a joint too much, sometimes the only remedy is to take out the flexible element and put in a rigid joint. (A metal to metal flange connection instead of a gasketed one, for example.)

Are you using more bolts than needed?



The stability of a 4 bolt arrangement can be matched by a 120° spacing of 3 bolts. Strength can be actually increased by using RB&W high carbon heat treated bolts (identified by "E" and three radial dashes).

NOBODY wants to use too few bolts or cap screws and risk failures. But using too many is not the best answer either. It means too many holes to drill, to fill — both costly.

RB&W offers some suggestions.

BALANCED BOLT PATTERN

By "rule of thumb," bolts are generally arranged symmetrically in a pattern of four. Yet three bolts 120° apart around a common center will prove just as stable, and save on assembly. With stability assured, the problem is then one of load capacity.

PRELOAD TO GET FULL CAPACITY

In checking size and number of bolts, calculate the stress and get rid of the excess. You have enough if you've allowed for usual factor of safety . . . *and the fasteners are tightened so that residual tension exceeds maximum external load anticipated.* If they are, you have safety. The bolts will *stay* tight, won't fatigue, won't fail.

With RB&W standard fasteners, engineers and production men can take quality, uniformity and dependability for granted — and can concentrate on the problem of proper application and assembly. For help or information on your specific product, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

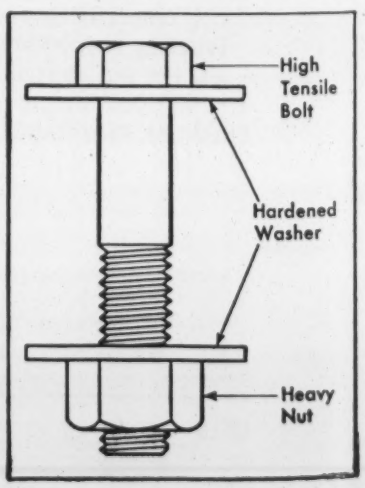
Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

High strength bolts stop joint failure from vibration

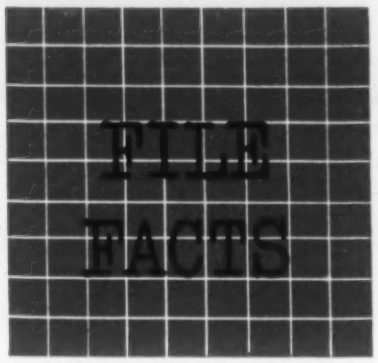
Shakeout equipment used by one company for unloading coal cars applied its vibration via a fabricated frame lowered onto the cars. This frame was originally riveted.

But it was a constant source of maintenance. About every 10 days, the frame had to be welded, loosened rivets replaced. Finally it was refastened with RB&W high tensile bolts and hardened washers. Maintenance now is *nil!*

Proving again that high strength bolts make the strongest connection for the severest service.



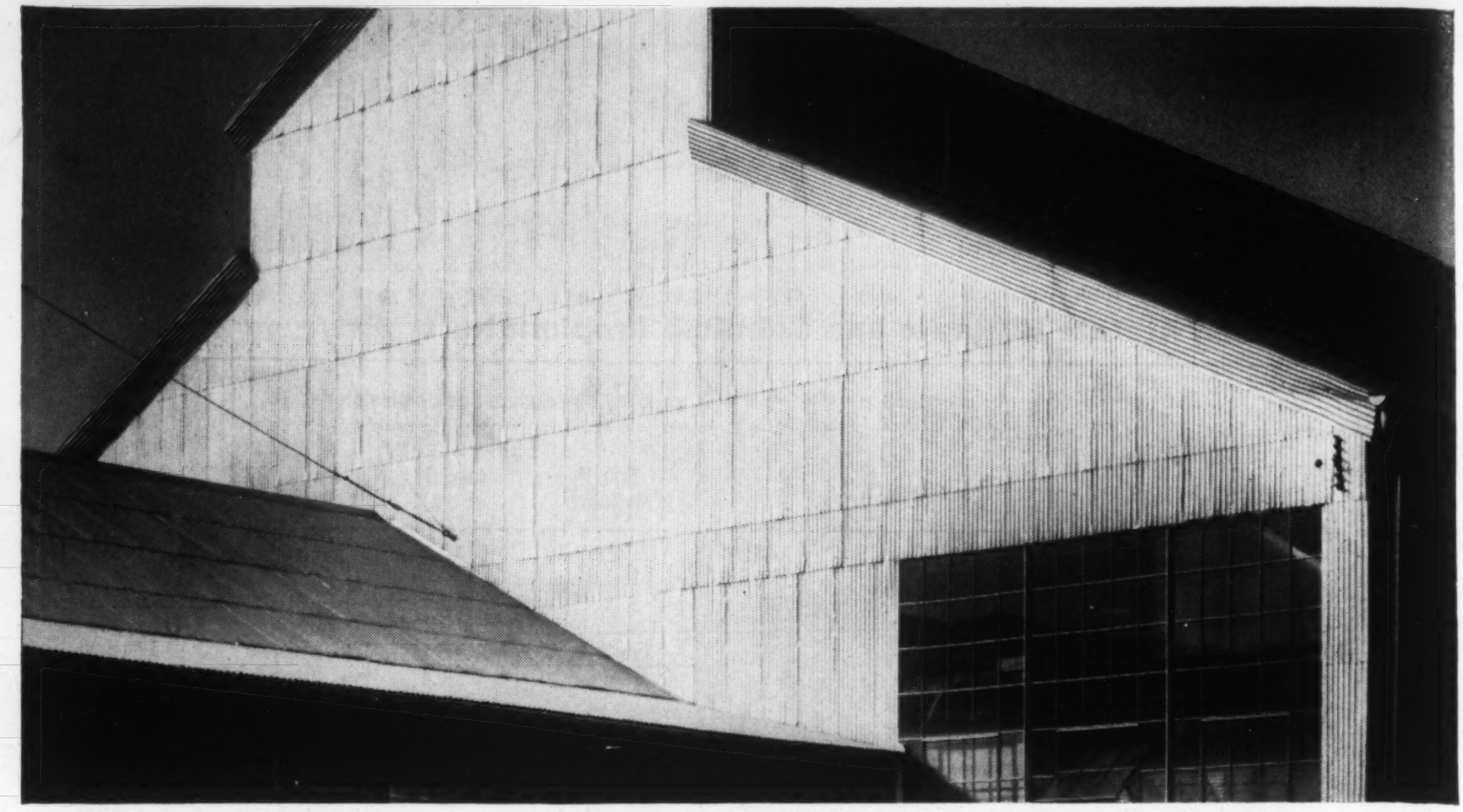
For more information, turn to Reader Service card, circle No. 511



Cellulose Acetate Butyrate and Cellulose Propionate

Type →		Cellulose Acetate Butyrate			Cellulose Propionate[b]
		Type I[a] (Medium)	Type II[a] (Hard)	Type III[a] (Soft)	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.16-1.24	1.19-1.25	1.15-1.22	1.18-1.24
Ther Cond, Btu/hr/sq ft/°F/ft	C177	10-19 x 10^{-2}	10-19 x 10^{-2}	10-19 x 10^{-2}	10-19 x 10^{-2}
Coef of Ther Exp (max), per °F	D696	6-9 x 10^{-5}	6-9 x 10^{-5}	6-9 x 10^{-5}	7-9 x 10^{-5}
Refractive Index	D542	1.46 1.49	1.46-1.49	1.46-1.49	1.46-1.48
Spec Ht, Btu/lb/°F		0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Transmittance (luminous), %	D791	80-90	75-90	85-95	80-90
Haze, %	D672	3-10	5-15	3-8	5-10
Water Absorption (24 hr), %	D570	1.3-2.1	1.5-2.2	1.1-2.1	1.2-2.0
Flammability, ipm[c]	D635	0.5-1.5	0.5-1.5	0.5-1.5	1.0-1.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	2.9-5.7	5.0-6.8	1.9-3.8	1.5-7.5
Elong, %		47-66	38-54	60-74	50-60
Hardness (Rockwell)		R79-112	R108-114	R59-95	R20-120
Impact Str (Izod notched), ft-lb/in.	D256	1.0-4.3	0.6-2.4	2.5-5.4	0.8-11.0
Mod of Elast in Flex, 1000 psi		93-168	148-199	74-126	160-330
Flex Str, 1000 psi		No break	No break	No break	No break
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{10}-10^{12}	10^{10}-10^{12}	10^{10}-10^{12}	10^{12}-10^{15}
Dielec Str (short time), v/mil	D149	250-400	250-400	250-400	300-450
Dielec Const					
60 Cycles	D150	3.5-6.4	3.5-6.4	3.5-6.4	—
10^6 Cycles	D150	3.2-6.2	3.2-6.2	3.2-6.2	3.4-3.6
Dissipation Factor					
60 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	—
10^6 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	0.02-0.03
FABRICATING PROPERTIES					
Bulk Factor		2.0-2.4	2.0-2.4	2.0-2.4	1.6-2.0
Compressive Molding					
Pressure, 1000 psi		0.5-5	0.5-5	0.5-5	—
Temperature, F		285-340	320-390	265-305	—
Injection Molding					
Pressure, 1000 psi		8-32	8-32	8-32	8-32
Temperature, F		355-440	390-480	335-395	310-480
Mold Shrinkage, in./in.		0.001-0.008	0.001-0.009	0.001-0.006	0.002-0.006
HEAT RESISTANCE					
Heat Dist Temp, F					
66 psi	D648	156-197	188-233	139-164	130-200
264 psi	D648	130-172	158-210	121-137	—
CHEMICAL RESISTANCE		Unaffected by 30% sulfuric, 5% acetic, 10% hydrochloric and oleic acids; discolored by 10% nitric acid. Unaffected by 1% sodium hydroxide and 2% sodium carbonate; slightly softened by 10% sodium hydroxide and discolored by 10% ammonium hydroxide. Unaffected by white gasoline, but swollen or dissolved by ethyl alcohol, acetone, ethyl acetate, ethylene dichloride, carbon tetrachloride and toluene. Unaffected by water, salt water and 3% hydrogen peroxide.			
USES		Telephone handsets, steering wheels, automobile white-wall disks, film spools, irrigation tubing, radio housings. Electrical items such as fluorescent light supports, coil spools and contact bases.			Pen and pencil parts. Other uses similar to those of butyrate.

[a]ASTM D707-55T.
[b]Values given are for compounds having different plasticizer contents.
[c]Self-extinguishing cellulose acetate butyrate compounds are available.



PAINT STAYS ON the metal of this galvanized building. The roofing and siding were treated with ACP Lithoform before painting. No peeling of the paint finish has occurred and it will last much longer

ACP Lithoform® REDUCES MAINTENANCE COSTS OF GALVANIZED IRON STRUCTURES— FIRMLY ANCHORS PAINT TO THEM

LITHOFORM PROCESS	Type of Coating	Metal Treated	Object of Coating	Method of Application	Government Specifications
LITHOFORM 32	Zinc phosphate	Zinc or cadmium	Improved paint adhesion	Spray Dip	MIL-T-12879 (QMC) Type 1, Class 1 QQ-P-416, Type 111 QQ-Z-325, Type 111
LITHOFORM 40	Zinc phosphate	Zinc and steel when combined	Improved paint adhesion	Spray Dip	MIL-T-12879 (QMC) Type 1, Class 1 PA-PD-191 (Rev. 1) (purchase description) QQ-P-416, Type 111 QQ-Z-325, Type 111
LITHOFORM Z	Amorphous chromate	Zinc or cadmium	Improved paint adhesion corrosion resistance unpainted	Spray Dip	MIL-C-17711 (N Ord.) MIL-T-12879 (QMC) Type 1, Class 2; Type 11 QQ-P-416, Type 11 QQ-Z-325, Type 11 U. S. A. 57-0-2C Type 1 (plating)
LITHOFORM 2	Zinc phosphate	Zinc	Improved paint adhesion	Brush	

There's no peeling of paint from galvanized iron, other zinc surfaces, or cadmium when they are first treated with Lithoform. This ACP product forms a non-metallic coating which becomes an integral part of the surface, resulting in an excellent bond for the paint finish and preventing any undesirable chemical reaction between metal and paint film.

LEARN MORE ABOUT ACP LITHOFORM. Bulletin 1481 describes the various types and gives helpful information which will help you select the proper one for your particular application. Write for your copy today

AMERICAN CHEMICAL PAINT COMPANY, Ambler 12, Pa.

DETROIT, MICH. • ST. JOSEPH, MO. • NILES, CALIF. • WINDSOR, ONT.

CHEMICALS ACP PROCESSES

New Chemical Horizons for Industry and Agriculture

For more information, turn to Reader Service card, circle No. 474

What's new IN MATERIALS

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Heavy section castings *of Climax 321, used as liners in ball mills, resist wear and erosion.*

White Iron with Molybdenum Has Improved Wear Resistance

What's new IN MATERIALS

■ A new iron alloy containing nickel, chromium and molybdenum is said to have better wear resistance properties than similar alloys not containing molybdenum. In addition, the alloy is reported to be well suited for heavy section castings and abrasion resistant castings of the martensitic white iron type.

The alloy, designated Climax 321 and produced by Climax Molybdenum Co., can be cast in either sand or permanent (chill) molds. When cast in chill molds, or against a chill, the carbide grain structure is refined, leading to improved toughness for certain applications. However, for most purposes, sand casting is preferred.

Structure

The microstructure of the new alloy consists of hard carbides in a matrix of martensite plus retained austenite. This microstructure, according to the producer, is responsible for the outstanding wear resistance of the material.

For most applications, the structure should be free from any graphitic carbon, which can seriously injure wear resistance. Graphite can be avoided by keeping the chromium in the specified range and by avoiding silicon or nickel contents above the ranges specified in the accompanying table.

Retained austenite, which is present in the matrix of all martensitic white irons, usually tends to lower wear resistance to some extent. The retained austenite in this composition can be minimized by holding the carbon content near the high side of the range and by holding the manganese and nickel contents in the lower side of the range. A refrigeration treatment provides an effective method of reducing the retained austenite content by transforming it to hard, wear resistant martensite.

Heat treatment

Simple shapes with light to moderate section thickness may be either cooled in the sand mold or shaken out hot and air cooled. Heavy sections, cylindrical shapes or other casting designs subject to possible cracking from residual stresses should be cooled slowly in the mold down to room temperature. All castings should be stress relieved at 400 to 450 F prior to shipment from the foundry.

For optimum wear resistance, the smaller castings may be refrigerated at –70 to –100 F.

Properties

Hardness — Hardness measurements on martensitic white irons do not provide a good indication of their abrasion resistance. However, for a specific composition, there is probably some correlation between hardness and wear resistance, so hardness measurements may serve a useful purpose when care is used in their interpretation.

COMPOSITION OF ALLOY 321 %

Carbon	3.30-3.60
Silicon	0.30-0.60
Manganese	0.50-0.80
Nickel	2.75-3.25
Chromium	1.75-2.25
Molybdenum	0.70-1.10
Sulfur	0.15 max
Phosphorus	0.30 max

The hardness of Climax 321 Alloy will normally range from Rockwell C 55-62. On the Brinell test with a tungsten carbide ball, hardness will normally be between 550 and 700. A refrigeration treatment will materially increase the hardness of this alloy to still higher values, because of transformation of retained austenite to martensite.

Abrasion resistance—Comparative tests on the new alloy used for ball mill liners and grinding balls (5-in. dia) indicate that this

material has excellent wearing properties. Since the alloy represents a relatively new development, service results in other applications are not yet available. However, laboratory studies on the structure of this iron and the known influence of the various alloying elements indicate the 321 alloy should have outstanding abrasion resistance and good economic possibilities in all those applications where the martensitic types of white iron are usable. Furthermore, the alloy is well balanced from a metallurgical standpoint; consistency of properties and performance may prove to be one of its most desirable characteristics, according to the producer.

New Ferroelectric Available for Electronic Devices

■ A new ferroelectric material known chemically as triglycine sulfate has good electrical, physical and mechanical properties that make it promising for switching circuits and memory devices. Discovered by B. T. Matthias, of Bell Telephone Laboratories, the material has good chemical stability and does not decompose when exposed to moisture or air.

Compared with barium titanate, the most popular ferroelectric crystal investigated to date, triglycine sulfate has a low coercive field (220 v per cm) that permits switching with low voltages (about 20 v). Since the actual power required for switching is very small, internal heating of the material is greatly minimized. Repeated switching of triglycine sulfate does not cause fatigue as does repeated switching of barium titanate. It is claimed that switching times of 1 to 2 microseconds can be attained easily with triglycine sulfate.

The Curie point of the material (point at which a material loses its ferroelectric properties) is about 116 F. However, by replacing some of the hydrogen atoms with deuterium, easily accomplished when the crystal is grown, the Curie point can be raised to 140 F. Although heating beyond the Curie point causes the material to lose its ferroelectric properties, these properties are said to be fully regained when the material is cooled.

According to Bell Telephone Laboratories, a memory or switching device capable of storing 900 or more "bits" of information on 1 sq in. of crystal can be made by evaporating the crystal onto thin strips of metal. A very compact assembly can be made using this technique.

***Crystal** of newly discovered triglycine sulfate ferroelectric material.*

Ferroelectrics

Ferroelectrics are materials that can be switched rapidly from one polarization to another by means of an applied voltage gradient of sufficient magnitude and proper polarity. They retain a given polarization until switched to another.

Tough Plastic Based on Silicon

■ A new silicon monomer designated Syl-Ken 21 is said to polymerize readily in bulk, emulsion and suspension to produce a clear, tough, highly water repellent plastic with a molecular weight of 600,000 to 700,000. When copolymerized with acrylonitrile, styrene, vinyl acetate or methyl methacrylate, it yields a plastics material with unusual properties. Developed by Dow Corning Corp., Midland, Mich., the material is currently available in pilot plant quantities.

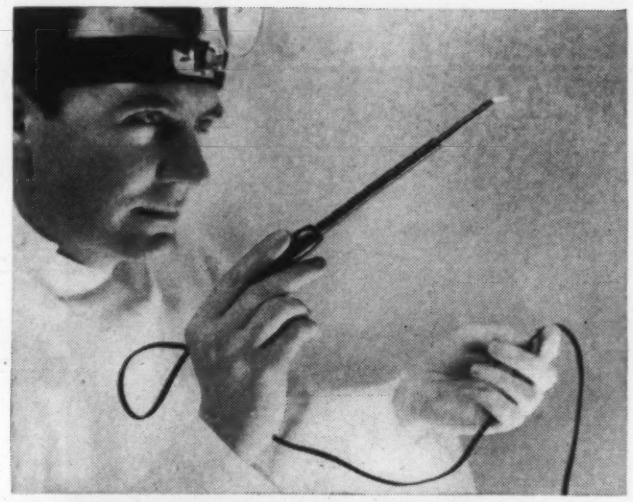
Said to be the first of a new family of silicon chemicals, the clear liquid monomer has a boiling point of 186 F and a density of 0.903, and is soluble in hydrocarbons, ethers and alcohols.

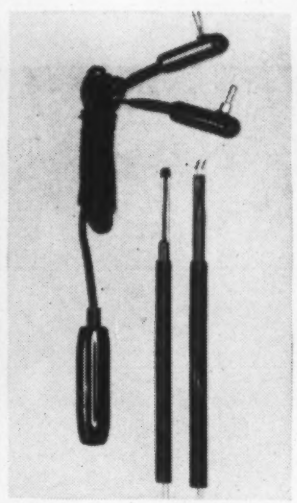
Preliminary tests show that the silicon monomer may be used to prepare new organic polymers with unusual bonding properties and surface characteristics. For instance, a 30% copolymer of the silicon monomer with methyl methacrylate has a coefficient of friction against steel of 0.03, as compared with 0.05 for polytetrafluoroethylene and 0.15 for polystyrene. According to the producer, vapors of this material are toxic only at high temperatures.

(more What's New on p 147)

CYANAMID

PLASTICS NEWSFRONT



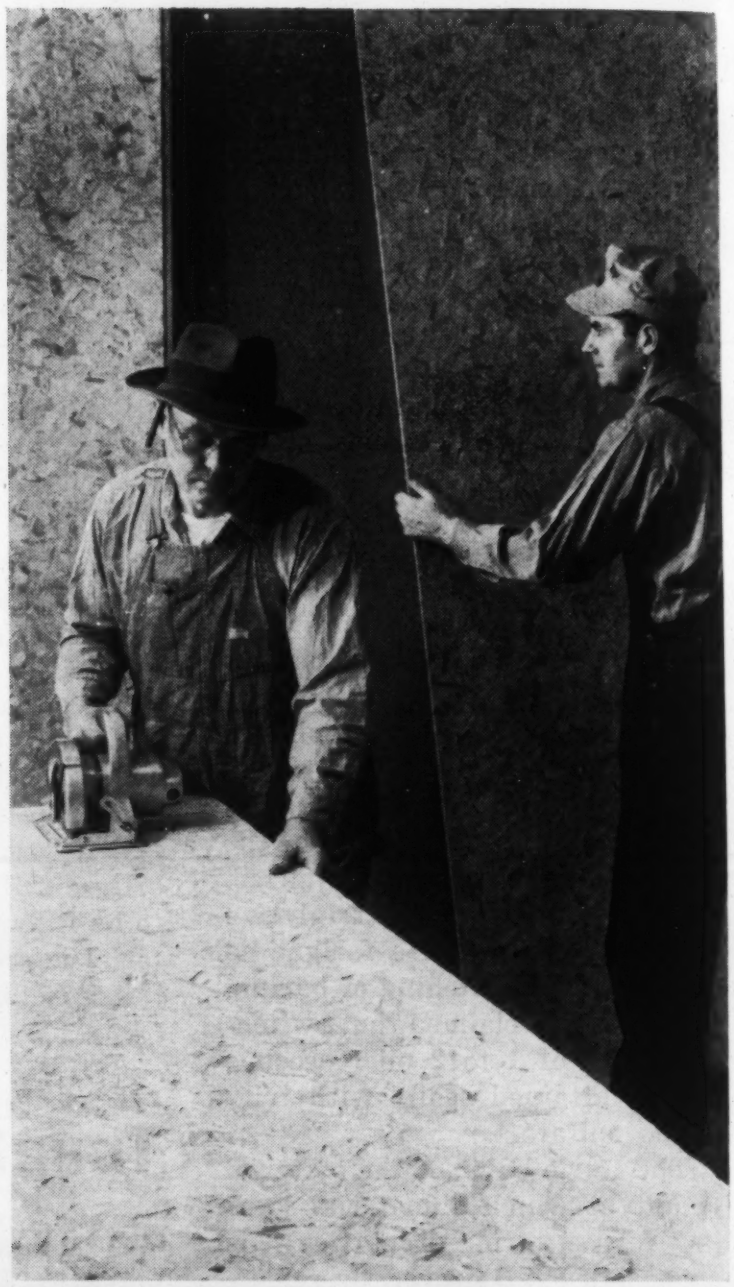


CYMEL* IN ELECTROSURGERY

High-frequency current flows between two sharp electrode tips in the 789 Bi-Active Coagulation Set used by physicians for removal of cervical cysts, tonsils and surface growths. The Birtcher Corp. of Los Angeles encases the electrodes in mineral-filled CYMEL Melamine Molding Compound because of its excellent insulating properties and smooth flow into the mold which simplifies accurate spacing of the tips. Handles and cord tips are molded of alpha-cellulose-filled CYMEL, also an excellent insulator. All surfaces are exceptionally hard, chip resistant and can be sterilized easily. *Trademark

MODERN TOUCH IN WIRING DEVICES

Home styling today favors light, cheerful colors. This note is carried out perfectly with wiring devices molded of ivory-colored BEETLE® Urea Molding Compound. Its hard, smooth surface resists discoloration and scratching, and safe dependable service is insured by BEETLE's excellent insulating properties.



WOOD CHIPS BUILD A WALL

These attractive panels are made of wood particles bonded with MELURAC® Melamine-urea Resin. This low-cost particle board has good warp resistance, flexural strength, moisture resistance and easy working and finishing properties. In addition to structural uses—walls, sliding doors, partitions, ceilings, subflooring, parquet flooring—it is ideal for furniture core and underlayment of decorative melamine laminates. MELURAC 304, developed expressly for this use, imparts no color and improves strength of the particle board.

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MATERIALS FOR TOMORROW

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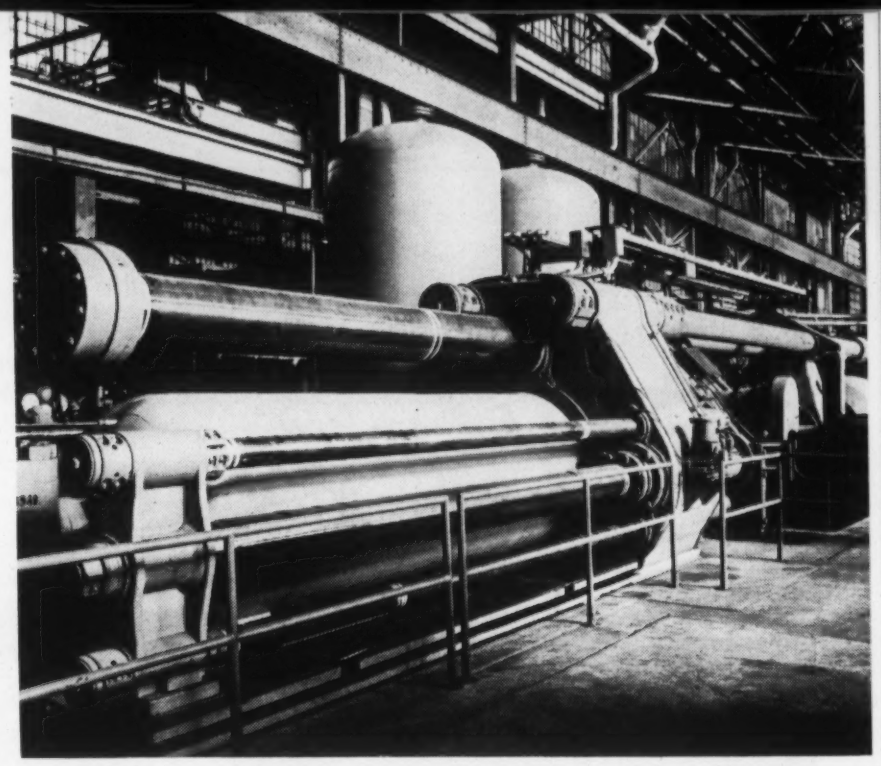


Integrally stiffened sections *produced by large press (right) mean more strength, simpler fabrication.*

World's Largest Magnesium Extrusions

■ The largest available magnesium extrusions are now being produced at Dow Chemical Co.'s Madison, Ill. Plant. A giant 13,200-ton press, claimed to be the largest magnesium extrusion press in the world, will be used primarily to produce integrally stiffened sections from 9 to 20 in. wide; I-beams from 11 to 28 in. high; and round tubing with outside diameters from 10 to 24 in.

In addition to the above, the press can extrude all shapes common to conventional equipment, plus several complex sections that previously required a series of separate operations. For example, the press is equipped with a double locking frame that enables it to produce stepped extrusions, combined hollow forgings, and hollow propellers. In addition, the high ratio of pressure to area in the press permits extrusion of extremely thin-walled shapes not possible with other equipment.

Teflon Films Preserve, Lubricate Weapons, Ammunition, Fasteners

■ Teflon, when applied as thin films to hard substrates, produces a dry, chemically resistant, all-weather lubricant that has remarkable preservative qualities.

The use of Teflon films for lubricating and preserving a wide variety of military equipment has been pioneered by the Naval Research Laboratory since the Korean war. In a recent interim report, NRL Report 4753, V. G. FitzSimmons and W. A. Zisman, of NRL's Chemistry Div., summarize the experimental work and field tests conducted on Teflon coated guns and ammunition, submarines, aircraft and other equipment.

The authors find that the coefficient of friction of a Teflon film when sliding against another film of Teflon on a hard substrate is 0.04 to 0.05 through a temperature range of 120 to 450 F. They say that "although Teflon coatings are certainly not a panacea for solving lubricating problems without the use of oils or greases, when properly used they are ideal in numerous lubrication applications of much value to the military and to industry."

PROPERTIES OF TEFLON FILMS

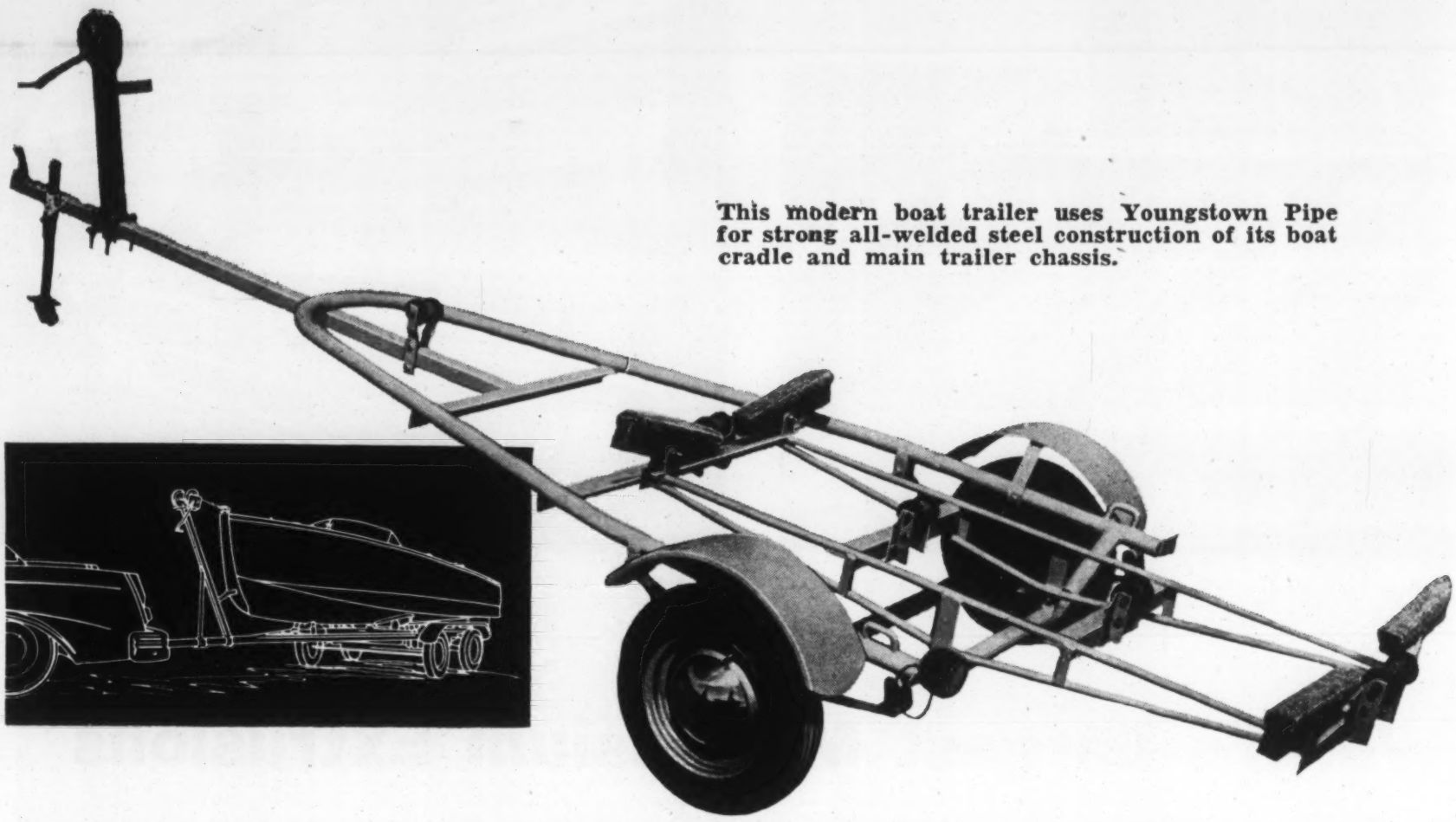
Tensile Strength, psi	3000
Elongation, %	250
Durometer Hardness	D 58
Tear Strength, psi	600
Power Factor (1000 cycles)	<0.0002
Dielectric Constant (1000 cycles)	2.1
Volume Resistivity, ohm/cm	$>10^{14}$
Water Absorption, %	0.000
Brittleness Temperature, F	<—100
Specific Gravity	2.2

Coated ammunition

During the Korean conflict a Naval Laboratory research team investigated the operation and lubrication of an aircraft cannon operating in the temperature range of –70 to 160 F. They found a need for an improved low temperature lubricant not only for the gun mechanism, but also for the cartridges, to decrease jamming tendencies.

After satisfactory techniques were developed by the Laboratory for applying Teflon coatings to brass and steel cartridges, the lubricating properties of the resulting cartridges were investigated exhaustively. A summary of the results:

1. Gun firing tests of brass



This modern boat trailer uses Youngstown Pipe for strong all-welded steel construction of its boat cradle and main trailer chassis.

YOUNGSTOWN CONTINUOUS WELD PIPE

. . . provides extra-strength chassis for "Texan" boat trailers

Here's an unusual application for steel pipe. "Texan" Boat Trailers, produced by the Cunningham Trailer Works of Lubbock, Texas, are fabricated from Youngstown Pipe to provide users maximum cargo protection as well as greatest ease during loading, unloading and while making the haul.

In line with Cunningham's policy of using only the highest quality raw materials, they wisely specify Youngstown Continuous Weld Pipe for fabrication of both the boat cradle and main trailer chassis. This gives Texan boat trailers a sturdy welded steel construction able to withstand the most rugged use—on or off the highway. Why not use Youngstown Pipe structurally to build strength and quality into your products?

Your local Youngstown Distributor is the man to call when you want quality pipe—day or night. He has a complete stock and his on-the-spot fast delivery will help keep your operations humming along at top speed. Why not call him today?

Next time you need pipe—for any purpose—specify Youngstown and secure these 7 Points of uniform goodness

uniform ductility
uniform lengths
uniform threading
uniform weldability
uniform wall thickness and size
uniform strength and toughness
uniform roundness and straightness

QUALITY YOUNGSTOWN SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY
Manufacturers of Carbon, Alloy and Yoloy Steel
General Offices - Youngstown 1, Ohio
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cartridges coated with one coat of Teflon show good performance and freedom from gun malfunctioning but do not show complete freedom from abrasion.

2. Teflon coated guns resist corrosion after 1000 hr in a standard salt spray chamber. When corrosion of steel coated with Teflon does occur, the damage is unlike that occurring on painted or enameled surfaces in that there is no lifting of the coating and no spreading of the corrosion to areas under the coating.

3. Short exposures at 1000 F do not damage the Teflon films in any way.

4. Teflon film does not crack or peel after thermal shock resistance tests, conducted by storing coated cartridges 24 hr at –70 F and then quickly placing them in boiling water.

5. No common lubricant or solvent softens the Teflon coatings.

Coated weapons

An extensive evaluation of Teflon coated weapons was made by both NRL and the Marine Corps. In the NRL tests the breechblock assembly of a new aircraft cannon was coated with the same two-coat system of Teflon used on steel ammunition. The breechblock was installed in the completely dry gun and 2000 rounds of ammunition were fired. At the end of the firing test there was no evidence of inadequate lubrication. NRL also conducted firing tests on a Teflon coated M-1 rifle and a Colt 45 automatic pistol. Firing tests showed that Teflon coatings provide good rifle and pistol lubrication, freedom from malfunctions and good rust protection.

The Marine Corps subjected Teflon coated weapons and weapon components to comparative tests, using parts lubricated with conventional materials. Firing tests of the coated rifles, carbines and machine guns were made under the most adverse conditions; the weapons were buried in sand, submerged for days in a chlorinated swimming pool and, except for the bores, never dried or cleaned afterward. Some rifles were fired so rapidly and for so long that the wood surfaces contacting the gun barrels were ignited. At the end of an eight month test period, only the weapons coated with Teflon were functioning satisfactorily.

Other uses

With respect to Teflon coatings on submarines, the authors find that although Teflon coatings on iron and steel offer valuable protection against the corrosive attack of moist air and water, they are not always adequate for shipboard uses involving frequent contact with the sea. Their use for lubricating outboard mechanisms on submarines is, therefore, not recommended unless the metal to be coated is itself highly resistant to sea water corrosion.

In addition to ammunition and weapons, NRL recommends Teflon coatings for lubricating and preserving parts of hydraulic and pneumatic systems of ships and aircraft; titanium nuts and bolts to prevent galling and seizing; many parts of the mechanism of torpedoes; fuel pumps and fuel meters; surgical instruments; bearings operated at low sliding speeds; and optical instruments.

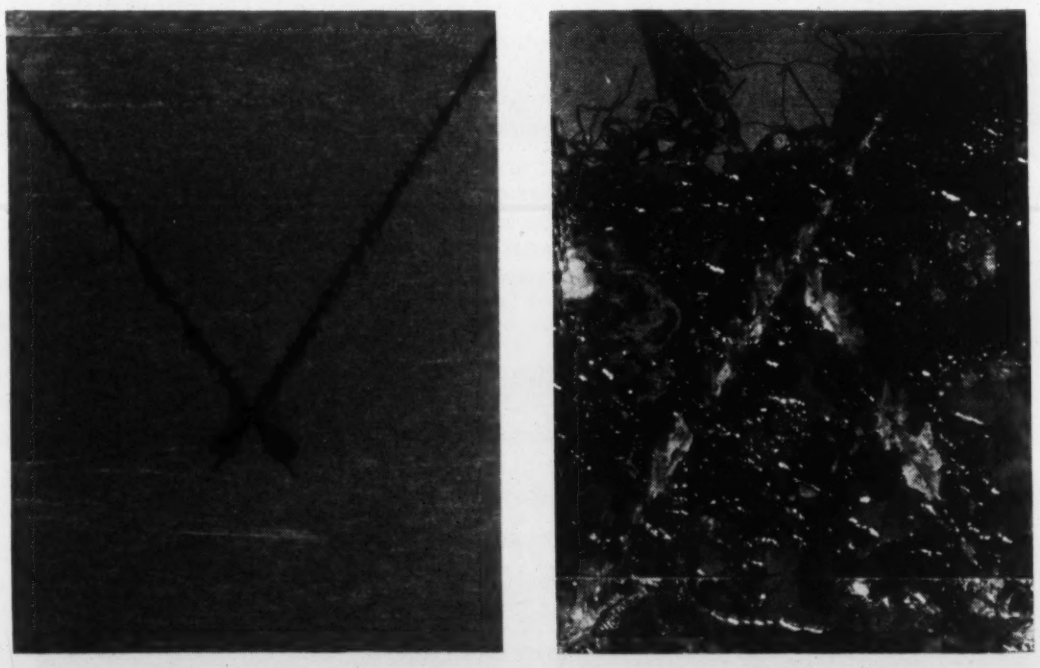
Inorganic Coating Competes With Tin Plating

■ A new coating process, claimed to be an effective substitute for tin plating, utilizes inexpensive and readily obtainable chemicals, requires a total processing time of only a few seconds and is carried out at room temperature.

The coating, developed by Heintz Chemical Research Dept., Heintz Mfg. Co., Front St. and Olney Ave., Philadelphia 20, consists of chromium compounds and can be applied to plain carbon steel, stainless steel, aluminum, zinc, magnesium, copper, or steel coated with these metals. Its greatest use is in the can industry.

Properties

The new coating, designated Hinac, is insoluble in water and



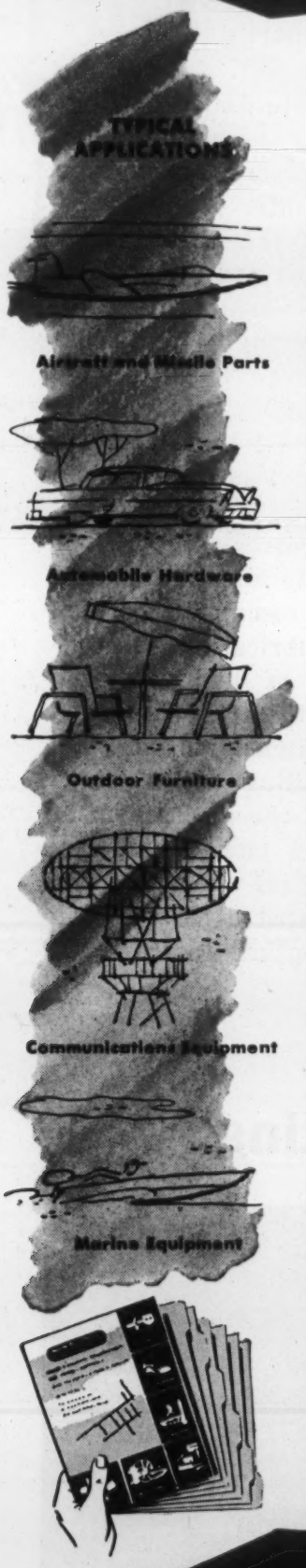
Hinac-treated *(left) and untreated (right) enameled blackplate after 18-hr immersion at 75 F in a corrosive solution (see text).*

look at these advantages of

IRIDITE FINISHES

for

CORROSION-RESISTANCE, PAINT BASE on ALUMINUM and MAGNESIUM



EASE OF USE—Iridite is a simple chromate conversion treatment. Fast, easy, economical. You just dip, brush or spray it on the part at room temperature. No special equipment. No specially trained personnel.

OUTSTANDING PERFORMANCE—Forms a film that is an integral part of the metal itself. Can't flake, chip or peel. Takes paint firmly on initial application, and the bond lasts. Even protects areas scratched in use.

LOWEST COST—You have only minimum equipment cost, no special racks, high speed operation, lower overall handling costs.

CHOICE OF APPEARANCE—Clear coatings that retain metallic lustre to dark, maximum protection coatings. A variety of colors is available by dyeing.

IRIDITE # 14 and # 14-2 (Al-Coat) for ALUMINUM

Two specially formulated finishes that give you maximum latitude in aluminum treatment. Both provide excellent corrosion protection and paint base. Iridite #14-2 is an improved product that allows greater flexibility in operation and coating thickness and produces the optimum in corrosion protection.
Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE # 15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

APPROVED UNDER GOVERNMENT AND INDUSTRIAL SPECIFICATIONS

SEE FOR YOURSELF WHAT IRIDITE CAN DO . . . SEND SAMPLE PARTS FOR FREE PROCESSING. Look at the results, test the protection, evaluate the savings. Also write for handy Reference File of the most complete data published on chromate conversion coatings. Or, for immediate information, call your Allied Field Engineer. He's listed under "Plating Supplies" in your classified phone book.

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Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ARP Plating Chemicals.
West Coast Licensee—L. H. Butcher Co.

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What's new IN MATERIALS

offers excellent chemical resistance, particularly to alkalis. Protection offered by the coating is high and is claimed to be superior to that obtained from conventional iron or zinc phosphate coatings. Lacquer, varnish or paint adhere well to the coating, and protection against underfilm (paint) corrosion is exceptionally good. The coating is smooth and imparts a high luster to a metal surface. Scratch resistance is superior to that of an iron phosphate coating of comparable coating weight.

The major disadvantage in the use of the coating is that coated surfaces are difficult to solder unless the coating is removed, either chemically or mechanically. However, Hinac-coated metals can be joined by welding; in most cases the coating improves weldability.

In a test to determine corrosion resistance, diagonal scratches were made through enameled surfaces of Hinac-treated and untreated panels of blackplate. The panels were immersed for 18 hr in a solution containing 3% sodium chloride and 0.3% hydrogen peroxide at 75 F. The panels were then rinsed and dried. As shown in the photo, corrosion in the Hinac-treated panel was limited to the actual scratches, with no underpaint film penetration. The untreated blackplate corroded completely under the enamel.

Applications

Although technical details of the new process have not been disclosed, the method seems to offer the advantages of conventional tinplating without the necessity for plating. The entire process is chemical and uses nonsludging and nonelectrolytic baths operated at room temperature; no molten metal is used. Composition and thickness of the inorganic coating can be varied to suit end requirements. As a result, its potential in the can industry is obvious. However, the coating can be used elsewhere. For example,

Another example of THERMALLOY quality control at work*

PREVENTIVE THERAPY

...the next "patient" can be your casting

Trained radiographers x-ray Thermalloy castings, such as pots and muffles, completely . . : not just at points of expected stress. *All* Thermalloy castings must pass x-ray inspection, surface tests or pressure tests, where experience indicates that stress can be normally expected.

Let us work with you on heat-treat problems. Our engineers can help you select the right grade of Thermalloy high-heat-resistant alloy and proper casting techniques for your particular application. Electro-Alloys has complete metallurgical and physical test labs, and works closely with the extensive headquarters research facilities of American Brake Shoe Company.

Call your nearby Electro-Alloys representative, or write for Thermalloy application bulletin T-225. Electro-Alloys Division 8028 Taylor Street, Elyria, Ohio. *Reg. U. S. Pat. Off.

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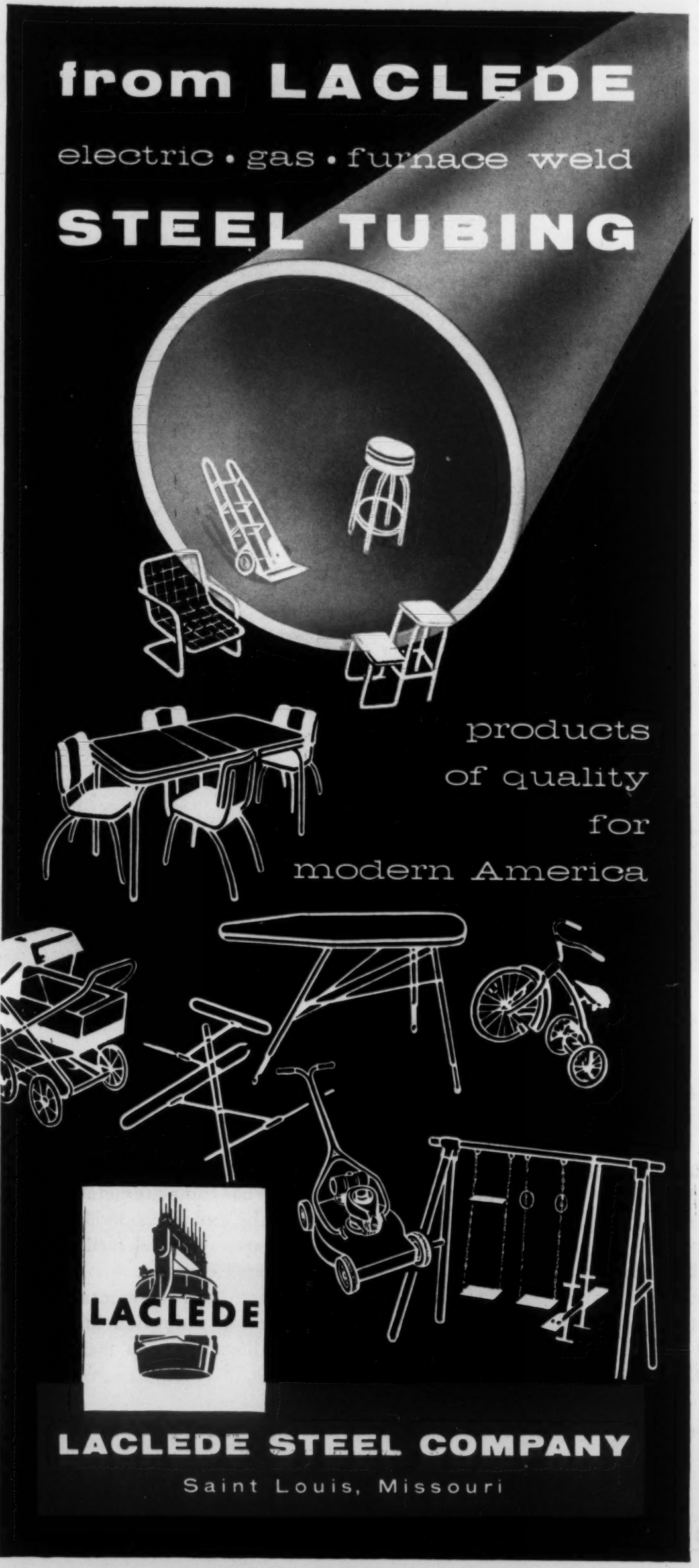

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What's new IN MATERIALS

since it is adaptable to high speed application, it is especially useful for treating strip on which both a high degree of corrosion resistance and good paint bonding qualities are required.

Laminated Teflon Film

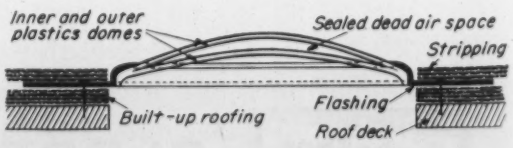
Laminated Teflon film is being marketed by Dilectrix Corp., Allen Blvd. & Grand Ave., Farmingdale, N. Y. Designated type CSC Teflon film, the material consists of a layer of sintered Teflon film bonded to a layer of partially sintered Teflon film. Suggested applications include high temperature wire insulation and thin wall flexible tubing. The film is available in roll lengths of 100 and 500 ft in widths from ¼ to 1 in.

New Plastics Skylight Keeps Buildings Cool

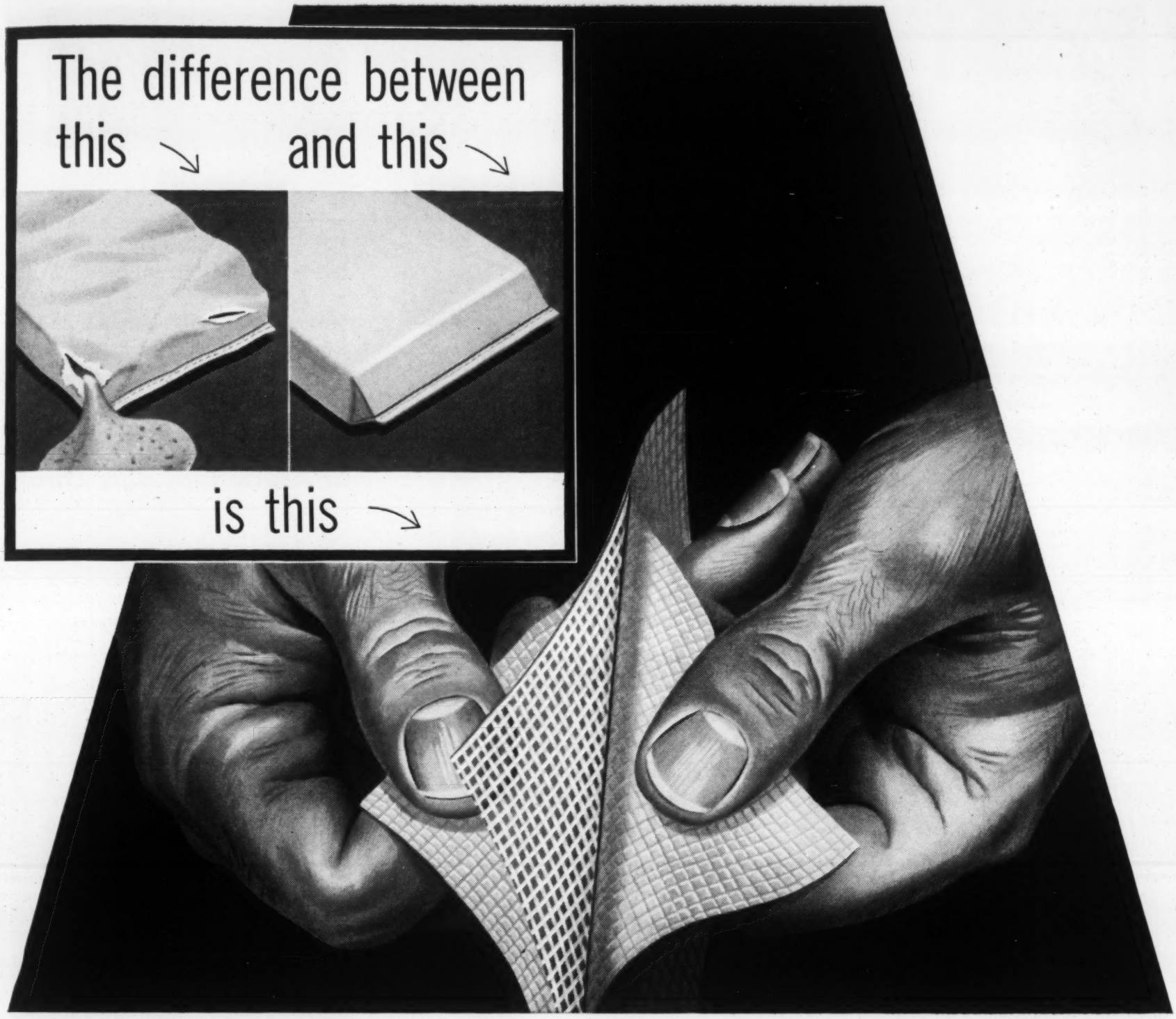
A new type of glass fiber-reinforced plastics skylight, based on the thermos bottle principle, is said to greatly reduce heating and air conditioning losses through conventional skylights. Dead air space between sealed inner and outer domes of the new skylight acts as insulation (see sketch).

The skylight is also said to provide a high level of diffused, natural light within a building and is claimed to lower the daytime cost of artificial illumination. Called the Consolite Double Dome Skylight, it is being marketed by Resolite Corp., Zelienople, Pa.

According to the company, the skylight cannot be shattered by ordinary hailstorms, rocks, shock



Construction *of plastics skylight.*



Avisco Rayon in scrim fabrics adds strength of steel mesh, flexibility of fabric to laminates and films

As a support for films, scrim fabric of Avisco rayon has an incredible tear strength and durability that makes tents, tarpaulins, awnings—practically every kind of covering—almost indestructible. It isolates puncture breaks immediately, makes possible on-the-spot repairs.

As a reinforcement for laminates, it permits the wrapping of products of every conceivable shape. This matchless flexibility is due to *creping after lamination*, which allows for extreme distortion in laminates without breaking or tearing. Creping also reduces areas of surface contact, so that abrasion damage is minimized.

The extra strength and impact resistance also result in *substantial savings in wrapping and shipping costs.* Fewer layers of wrap are needed in bagging such products as cement, fertilizer, and other granular materials. That means less weight to ship, lower freight charges.

Scrim of Avisco rayon is a "magic ingredient" that can open up markets overnight. By "upgrading" films and laminates, it creates a new world of uses for these products.

Want to know more about scrim fabrics of Avisco rayon and what they can do for *your* products? We'd be glad to help. The technical services of American Viscose are yours for the asking. Just fill in the coupon and send it in. You'll hear from us immediately.

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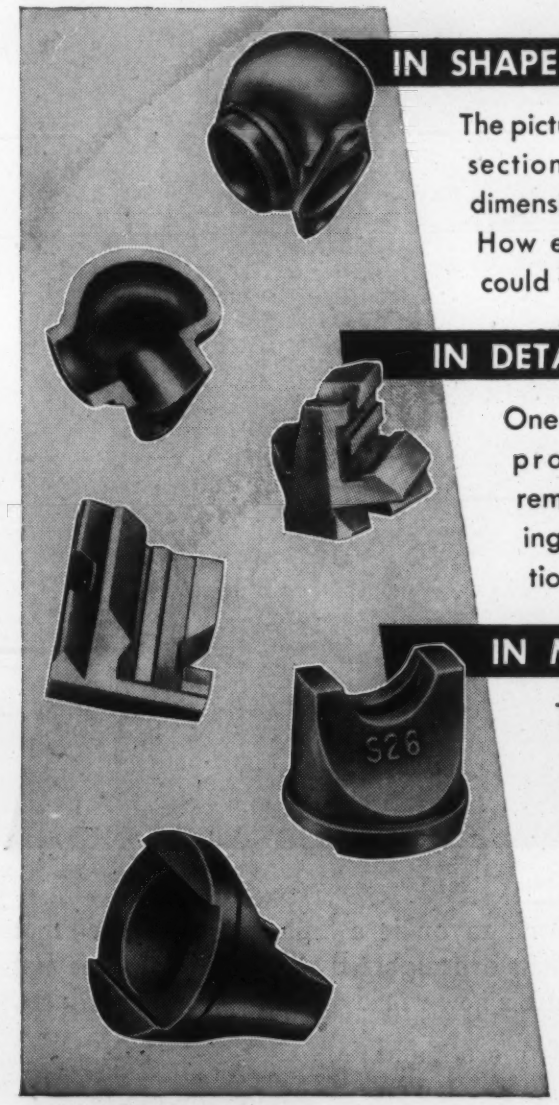
HERE'S HOW...

INVESTMENT CASTING ANSWERS DESIGN PROBLEMS

Investment Casting is a specific production method that fills a specific function. This process offers much greater latitude in shape, detail reproduction and choice of alloy than any other process.



IN SHAPE

The picture tells the story . . . from the cross section it can be seen that the inside dimensions are greater than the holes. How else but by Investment Casting could this be made in one piece?

IN DETAIL REPRODUCTION

One look quickly shows the machining problems — most of them stock removal. By using an Investment Casting 21 out of 45 machining operations were eliminated.

IN MATERIAL

These nozzles for a highway striping paint sprayer, were produced from cold rolled steel until ground glass was introduced into the paint for its reflective properties. To provide necessary wear resistance these parts are now cast in a non-machinable alloy. Performance was not sacrificed because of material limitations.

These are a few examples demonstrating that the function of the part is the first consideration in design — and — the Investment Casting process was the economical answer.

For more information ask for our brochure . . . its FREE of course.

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MILFORD 3, NEW HAMPSHIRE
REPRESENTATIVES IN PRINCIPAL CITIES

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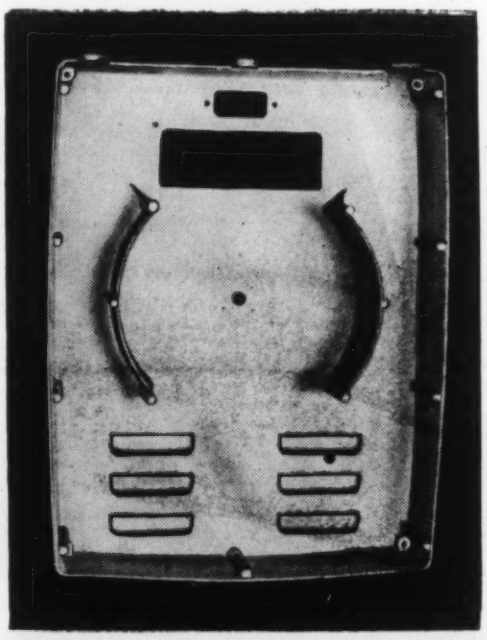
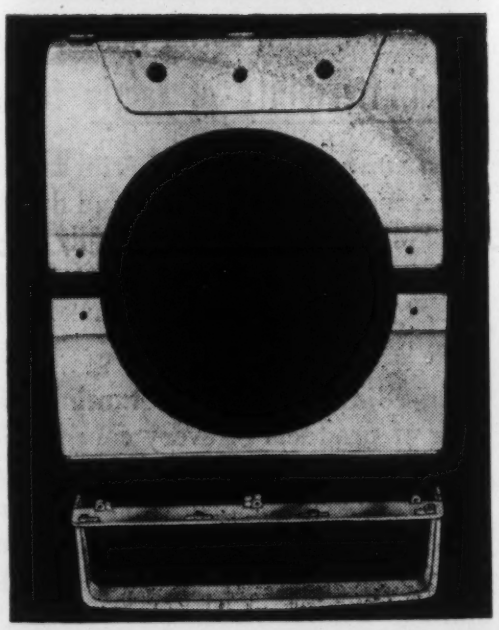
or vibration. The reinforced plastics material used in the skylight has a flexural strength of 20,000 psi and a tensile strength of 10,000 psi. It will support a dead load of at least 200 lb per sq ft.

Sterilizer Unit Die Cast of Aluminum and Zinc

For the first time die castings are being used to house medical and dental sterilizer units, ac-





***Die castings** in sterilizer unit: aluminum back housing (top), chromium plated zinc top instrument housing and aluminum housing covers (bottom); aluminum locking bar and door are not shown.*

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CAMBRIDGE 42, MASSACHUSETTS

...from Columbia-National

Up-to-date information about commercial-grade zirconium is summarized in a new, easy-to-use booklet.

Featuring:

- established and suggested uses
- corrosion resistance data
- physical and mechanical properties
- fabrication techniques
- Columbia-National technical service

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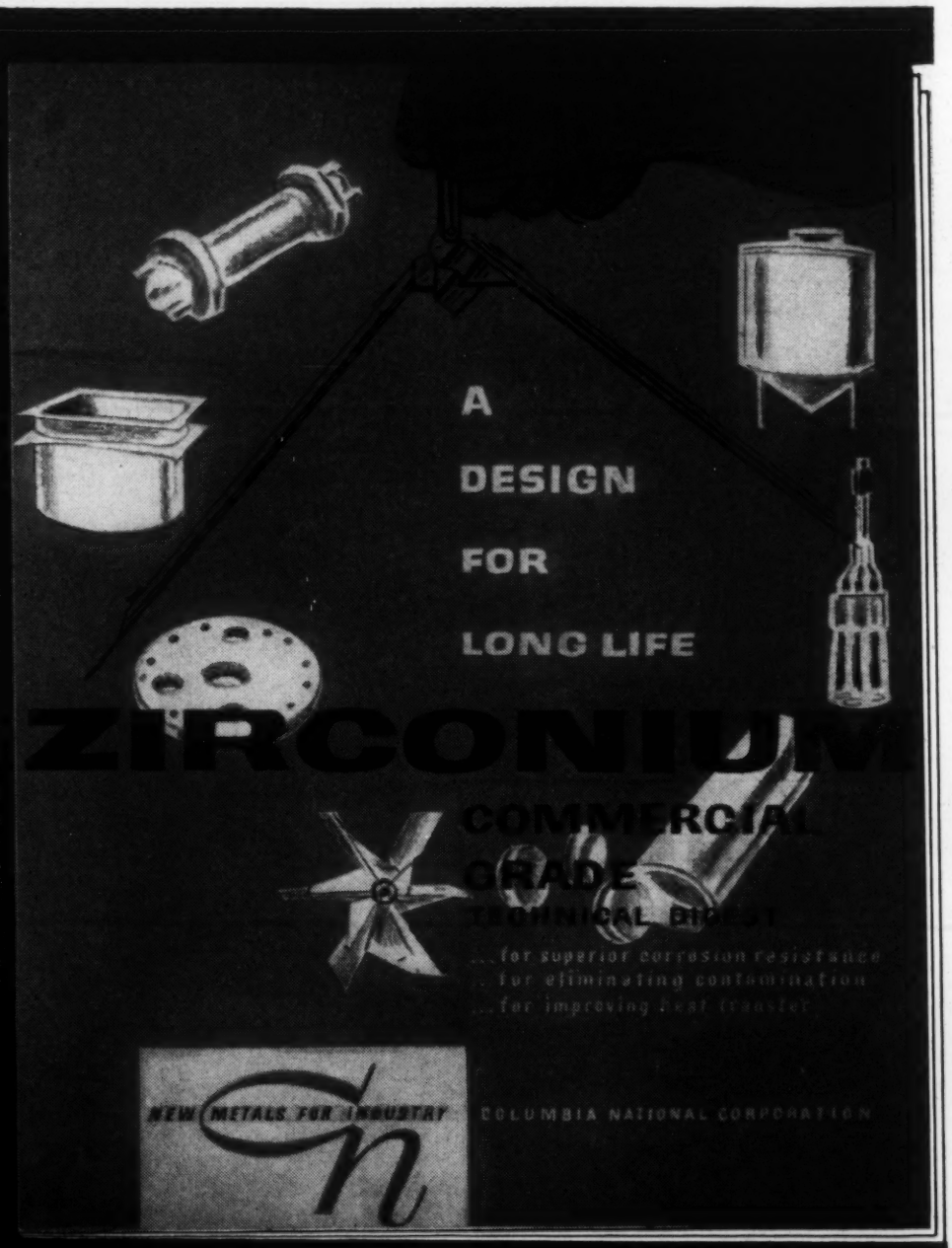
The coupon at the top puts your name on our mailing list to receive future bulletins. A folder on reactor-grade zirconium is also available.



NEW METALS FOR INDUSTRY

Columbia-National Corporation

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70 MEMORIAL DRIVE, CAMBRIDGE 42, MASSACHUSETTS

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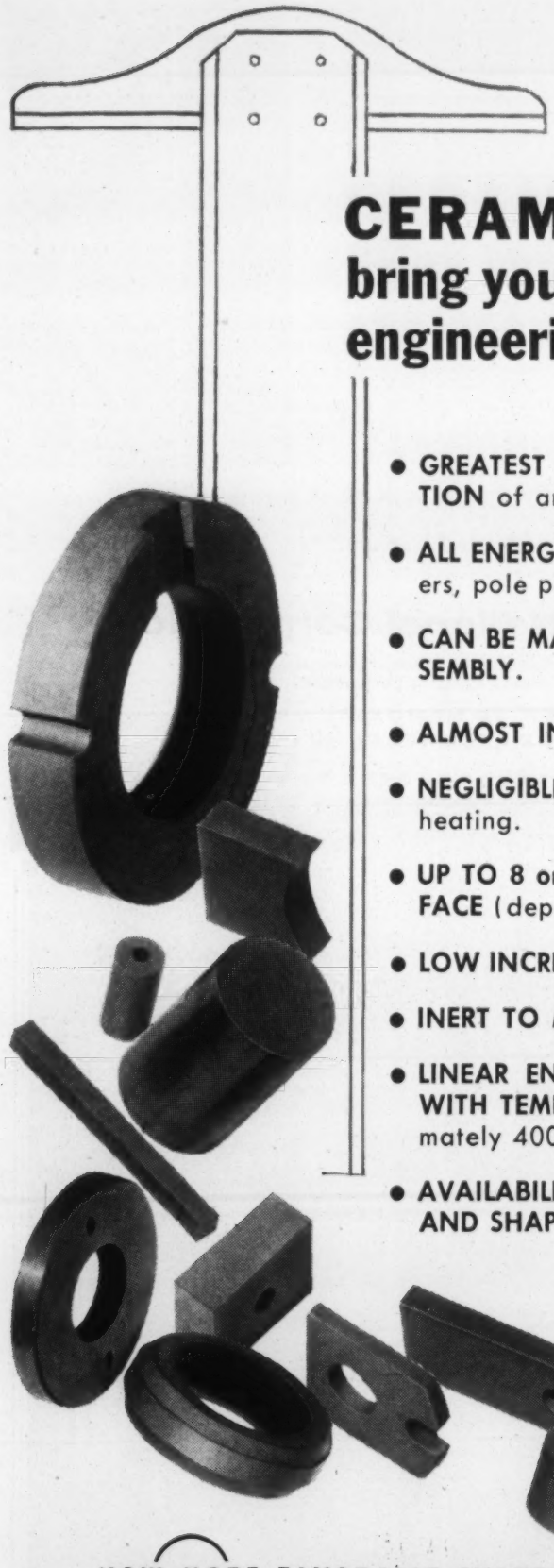

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bring you these design and engineering advantages...

- **GREATEST RESISTANCE TO DEMAGNETIZATION** of any commercial magnetic material.
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- **CAN BE MAGNETIZED BEFORE OR AFTER ASSEMBLY.**
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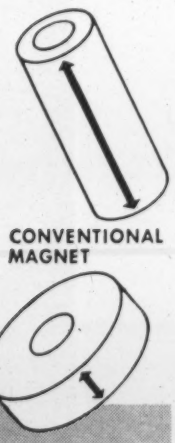
- **AVAILABILITY IN PRACTICALLY ANY SIZE AND SHAPE** . . . at minimum cost.

Write on company letterhead for Stackpole Ceramagnet Bulletin RC-11A.

HOW MORE FAVORABLE SHAPES OFTEN SIMPLIFY EQUIPMENT DESIGN

In many cases, Ceramagnet permits design improvement or space saving, thanks to the fact axial dimensions of the magnets may be reduced and radial dimensions increased correspondingly for more favorable shapes as indicated by the accompanying sketches.



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cording to Wilmot Castle Co. Developed by Wilmot in association with Precision Castings Co., the units are composed of six die castings. Five of these, which make up the back, front and door, are solid aluminum. The sixth, the top instrument housing, is chromium plated zinc.

Advantages claimed for the die castings include: 1) improved safety and protection from heat; 2) simplified design; and 3) reduced costs.

Epoxy-Paper Laminate for Printed Circuits

An epoxy resin-impregnated paper has been developed for printed and etched circuits that is said to have good electrical, mechanical and fabricating properties. Designated Nelco 130, the resin-impregnated paper is available in sheet form from New England Laminates Co., Inc., 481 Canal St., Stamford, Conn.

According to the producer, no blistering takes place when translucent and copper-clad Nelco 130 sheets are dip soldered at 520 F for 15 sec. The sheets have a water absorption of 0.25% after 24 hr immersion in water at room temperatures. The material can be cold punched in thicknesses up to 1/16 in. without cracking. It is available in 36 x 42-in. and 36 x 48-in. sheets and half sizes of these sheets.

Crepe Masking Tape Is Heat Resistant

An improved high temperature masking tape with better resistance to adhesive transfer and easier removal properties has been announced by Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn. Designed especially for critical high temperature

Big Squeeze Doesn't Flake Zinc Coating on Armco ZINCGRIP Tubing

Any product or part made from steel tubing can be made from zinc-coated Armco ZINCGRIP® Steel Tubing, *with no loss of zinc protection during fabrication.* Here's proof:

With a powerful squeeze in a machine, a six-inch length of ZINCGRIP Tubing folded like an accordion into a one-inch section. The steel didn't crack. *And there was no evidence of flaking or peeling of the tight zinc coating, at the weld or anywhere else.*

You can be sure this special zinc coating will hold just as tightly on any tubular products *you* fabricate. This means your finished products will be protected against corrosion without painting. Other special coated Armco Tubing grades also offer protection against corrosion.

Two Aluminum-Coated Grades

Armco ALUMINIZED STEEL® Type 1 Tubing (hot-dip aluminum-coated) is made from a special steel created to withstand combinations of heat and corrosion. For tubular products in outdoor service, Armco ALUMINIZED STEEL Type 2 Tubing offers resistance to atmospheric corrosion.

Take advantage of the high strength and light weight of corrosion-protected Armco Welded Steel Tubing in products or parts *you* make.

For complete information, just call your nearby Armco Sales Office or fill in and mail the coupon.

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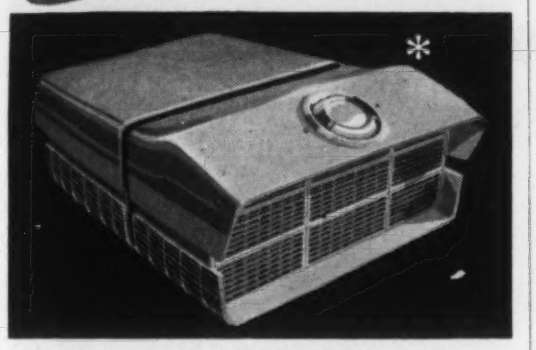
Idea!

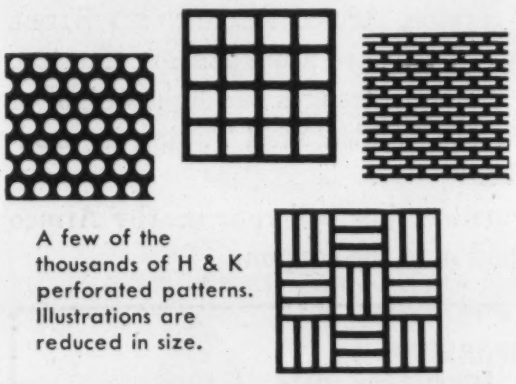


room air conditioning unit using H & K perforated metals

In the ¾ ton window air conditioner illustrated, perforated metals have been combined successfully with injection moulded plastics. The utilization, here, of new louvered perforated metals in adjustable frames on the frounced surface in combination with new embossed patterns on sides and under surfaces, afford rich tactile qualities hitherto unattainable in the air conditioner field.

Harrington & King perforated metals provide the Industrial Designer and other men of ideas unlimited opportunities to offer both functional and aesthetic properties as demanded in products for today's market. Contact H & K for your perforating requirements.

*Product Development by William M. Schmidt Associates



A few of the thousands of H & K perforated patterns. Illustrations are reduced in size.

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☐ STOCK LIST of Perforated Steel Sheets

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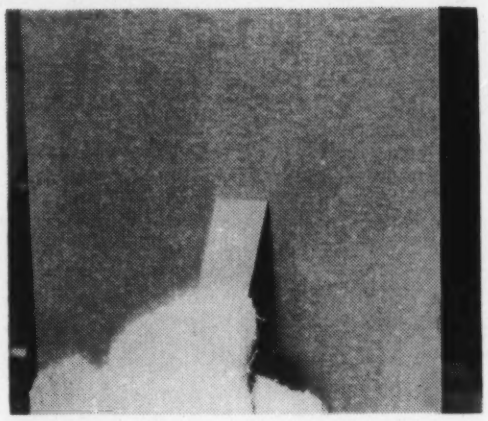
What's new IN MATERIALS



***Masking tape** peels normally even at temperatures as high as 300 F.*

masking conditions, the tape, known as Scotch brand masking tape No. 214, is recommended for use at temperatures up to 300 F.

The improved tape, consisting of a patented crepe paper backing and a pressure sensitive adhesive, is used to mask treated, as well as plain, metal surfaces. According to 3M, it can protect electrical parts during varnish dip and subsequent bake cycles, hold textiles during high heat pleating operations, and be used for outdoor masking of up to one month duration. The tape has a tensile strength of 20 psi, an adhesion to steel of 25 oz per in., and an elongation of 9%.

Two New Adhesives for Bonding Plastics

Adhesive Products Corp., 1660 Boone Ave., New York 60, has recently announced the development and improvement of three adhesives for bonding urethane foam and other plastics to wood, metal and concrete.

One adhesive, called Flok-Grip, is used to bond such materials as cotton, synthetic fiber flock, plastics and glass beads, plastics petals, confetti and other decorative materials to natural wood branches, leaves, evergreens, artificial flowers and plaster ornaments. The material, a water-

Now... **HARD BRIGHT GOLD** *with All the Attributes*

In Technic HG Gold you will find *all* the attributes you have needed in hard bright gold:

TECHNIC HG GOLD QUALITIES

Bright smooth-grained deposits
Super hardness: 130-150 DPH
Low stress, less porosity than usual bright gold
High karat: 23+

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Wide operating range (60° to 95° F), no cooling or heating required
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No organic brighteners
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Only Technic HG Gold fills all your requirements . . . find out for yourself that it is everything a hard bright gold should be.

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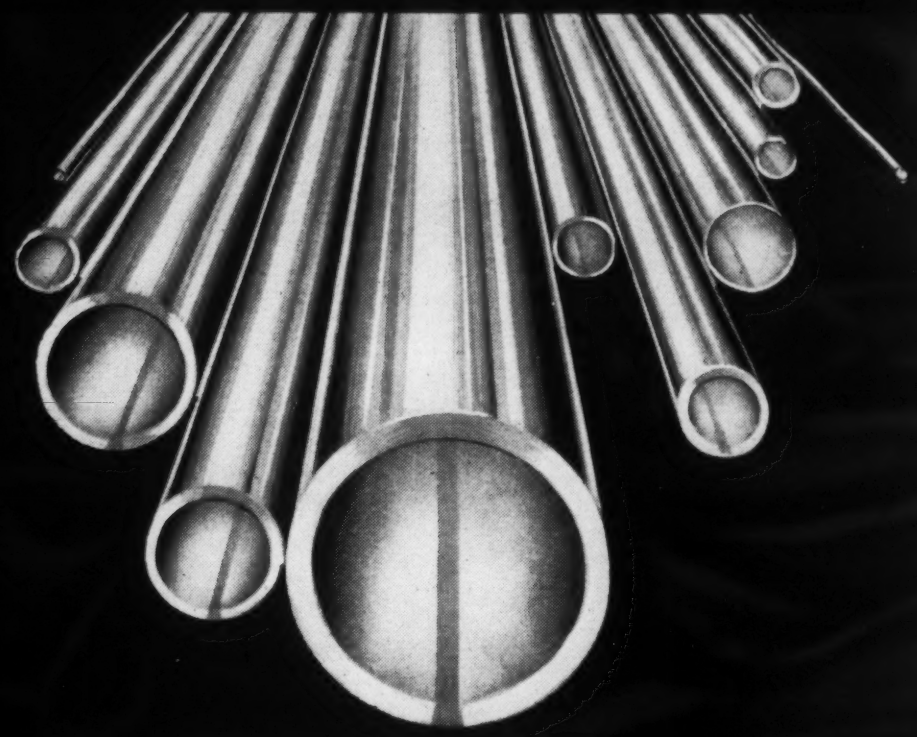
New book tells full story of stainless pipe and tubing



CONTOUR TRENTWELD

STAINLESS and HIGH ALLOY
PIPE and TUBING
1/8" to 40" O.D.

TRENT TUBE COMPANY *East Troy, Wisconsin*
SUBSIDIARY OF CRUCIBLE STEEL COMPANY OF AMERICA

If you use stainless or high alloy pipe or tubing, this new illustrated handbook was written for you. It's 58 pages big – packed with informative data that you'll refer to again and again.

The table of contents is too long to list here, but it includes, for example, analysis and conversion tables, corrosion characteristics, weights, alloy properties, bending, joining and installation hints.

We can't guarantee how long the supply will last. To be sure of getting your free copy, why not clip and mail the coupon now?

CONTOUR TRENTWELD **TRENT TUBE COMPANY**

A Subsidiary of Crucible Steel Company of America
GENERAL OFFICES: EAST TROY, WISCONSIN
MILLS: EAST TROY, WIS.; FULLERTON, CALIF.

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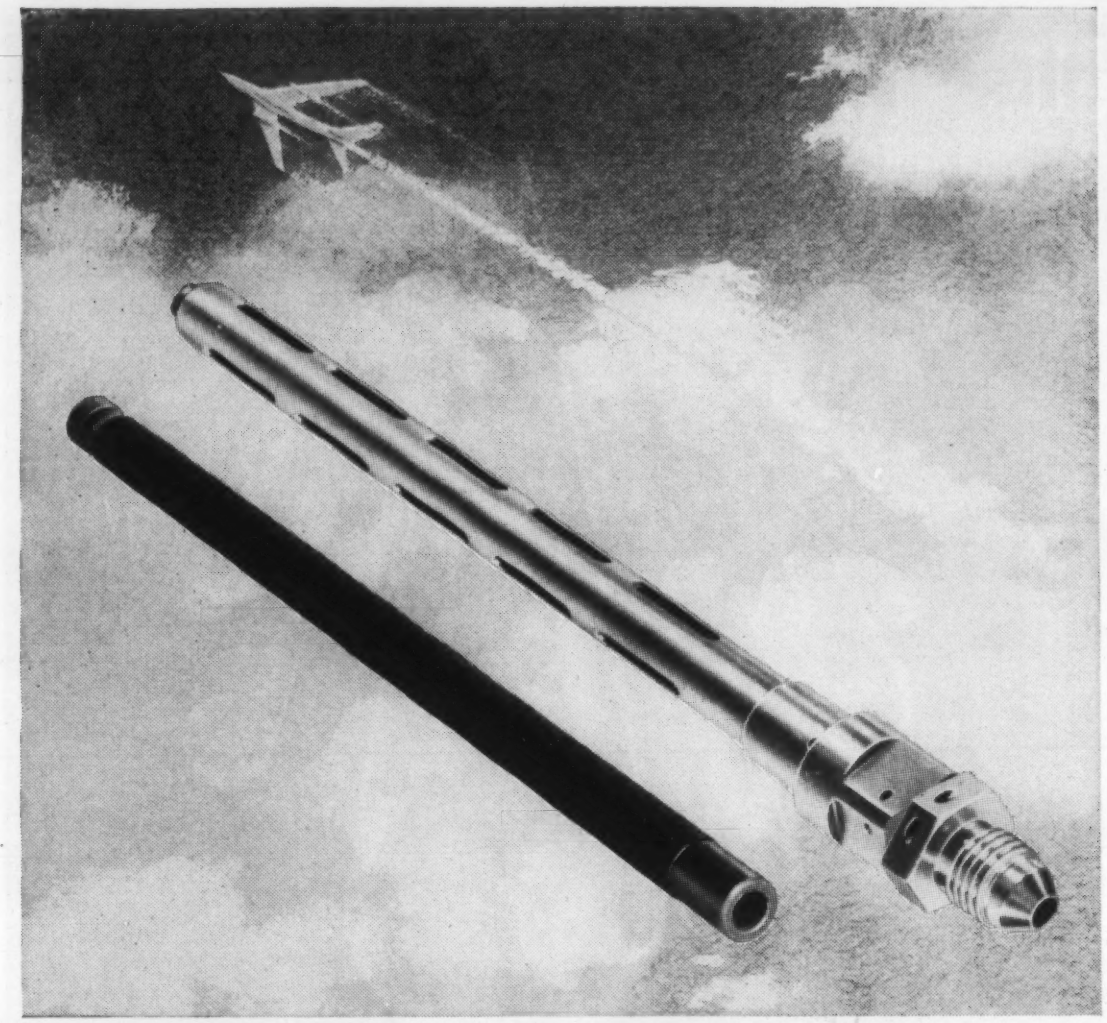

"FEVER THERMOMETER"

for supersonic jets

In order to break sound barriers, jet engines must break some temperature barriers, too—which brings some real problems in material selection. Any thermostatic control in the jet stream must withstand temperatures of 2000° without significant change in properties and characteristics.

Faced with this problem, one of the world's leading designers and manufacturers of aircraft components and systems has made Kennametal* a "Partner in Progress"—and has found an answer. For a vital part of the sensing element in a thermostat assembly, a small tube of Kentanium* is used. This material, one of a big family of unusual carbides developed by Kennametal, retains its responsiveness and reliability through the entire flaming range of operating temperatures.

Perhaps you have some new product in mind that is still on the drawing board for want of materials with the necessary properties to meet an unusual operating condition. If you need superior corrosion or erosion resistance, hardness, strength and stiffness, or resistance to elevated temperatures, chances are you can find the needed combination of properties in the Kennametal line. Just write, outlining your problem, to KENNAMETAL INC., Department CE, Latrobe, Pa.

*Kentanium and Kennametal are the trademarks of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

C-3044A

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...Partners in Progress

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base adhesive, is flame and water resistant.

The other adhesive, Styrogrip, is used to bond urethane foam to plywood, iron and concrete block. It is claimed that the adhesive does not attack the foam at either room temperature or 140 F.

Evaluating Glass Flakes as Reinforcing Agents

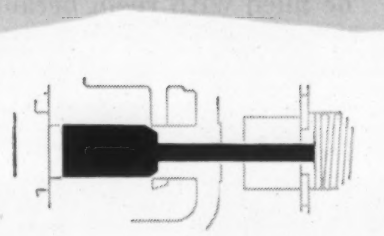
The possibility of glass flake-reinforced plastics looks promising at this time. Although there are many problems in producing a good glass flake plastics laminate, such a material can be made with some interesting properties, the most important of these being equal strength in all directions. Current research is centered around getting improved glass flakes and in developing better techniques of impregnation to impart the strength of the flake to the laminate (see MATERIALS & METHODS, Apr '57, p 254).

Advantages of glass flakes

The advantages of using glass flakes as reinforcing agents in plastics were discussed recently by George Rugger, Plastics Research section, Picatinny Arsenal, at the 13th Annual Technical Conference of the Society of Plastics Engineers. Mr. Rugger gave a number of reasons for using glass flakes rather than glass fibers as reinforcing agents in plastics.

The first of these is that glass flakes have multidirectional properties as contrasted with uni- or bi-directional properties of glass fibers. In ordinary glass cloth laminates, one-half of the glass fibers contribute to the weight of the reinforced plastic but contribute nothing to its strength. In glass flake-reinforced plastics each glass flake particle contributes to the strength of the plastics laminate. With glass fiber-reinforced plastics large voids have to

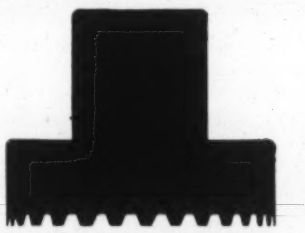
Here's a liftable idea for you in



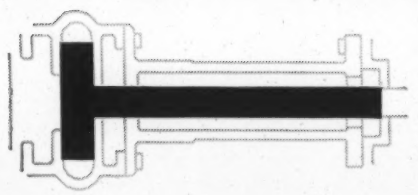
Piston for hydraulic control valve

One-piece bevel gear and shaft

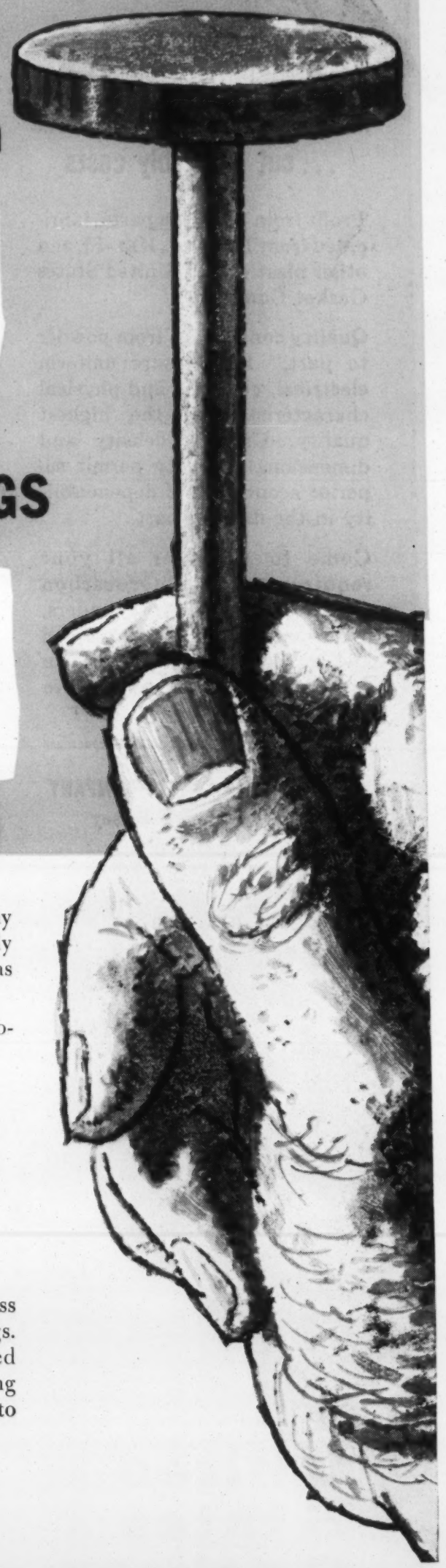
LARGE-HEAD STEEL FORGINGS



Spline-toothed coupling and shaft



Integral pump gear and shaft



A one-piece steel forging is probably the cost-reducing answer to many a part you now make by assembling a shaft to a thick disk or by costly machining from expensive bar stock. Above are sketched some ideas of uses for large-head steel forgings made by the Valve Division.

Advantages of one-piece extruded forgings over your present two-piece assemblies include:

Elimination of fitting and assembly,
Continuous grain structure around neck,
Only one part to machine,
Reduction in costly machining,
Elimination of costly scrap generation,
Improved structural strength,
No loosening of head on shaft.

Interested? Then let us send a Valve Division engineer to discuss the mechanics and economics of switching to large-head forgings. They are made in the same Valve Division plant that has produced over 1 billion large-head forgings as engine valves for all leading truck, automobile, aircraft, and industrial-engine builders. Write to Department MM-157 at the address below.

Valve Division ***Thompson Products, Inc.***

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precision

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Profit from precision parts, fabricated from TEFLON*, KEL-F†, and other plastics—by United States Gasket Company.

Quality controlled "from powder to part," they assure uniform electrical, chemical and physical characteristics of the highest quality. Uniform density and dimensional stability permit superior accuracy and dependability in the finished part.

Come to USG for all your requirements — Fluorocarbon sheet, tape, tubing, cylinders, rods, bars—as well as molded and machined parts to your own specifications. *Write for Bulletin No. IN-554.*

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UNITED STATES GASKET COMPANY
Camden 1, New Jersey

United States Gasket *Plastics Division*
OF THE GARLOCK PACKING COMPANY

be filled with resin because of the cylindrical shape of the glass fiber. This is not the case with glass flakes which have the ability to pack closely. This ability to pack closely permits a stronger adhesive bond of the resin to the reinforcing agent.

Epoxy resins best

Mr. Rugger revealed that epoxy resins are better to use with glass flakes than polyester resins. For instance, adhesion between epoxy resin and glass flakes is strong enough to cause breaks through the flake (in testing) even without a finish on the flake. He also found that epoxies wet the glass well enough to greatly reduce air bubbles. With use of epoxy resins, high percentages of glass flakes—up to 80 and 90% by weight—can be incorporated into the resin. However, it is rather difficult to form a flat panel of fiberglass laminate containing more than 65% glass flakes.

With respect to optimum resin layer thickness, Mr. Rugger found that 30 to 60 microns thickness is the critical range where fracture changes from propagation in glass to propagation in resin. Below 20 microns thickness, fracture is confined almost exclusively to the glass.

In the preparation of glass flake laminates, Mr. Rugger recommends that large areas of unfilled resin should be avoided if uniformly strong glass flake laminates are to be obtained. Bending and burst tests show that the strength of the glass flake is not the limiting factor in producing high strength laminates, as the strength of the flake is greater than that of the laminate.

Price comparison

Another advantage of using glass flakes as reinforcing agents for plastics is their relatively low cost when compared with glass fabric and mat (see table). The material is cheaper than any

For more information, turn to Reader Service card, circle No. 480

WAITING FOR A CHANGE

Development of aircraft and aero engine design is a pattern of never ending changes and modifications. Improving engines and airframes demands more strength in more and better parts. Example: There are about 1,300 machined parts in the F-100A. In the F-100D, improvements have added 500 more. Higher power and speeds in the same size airframe call for improved elevated temperature performance in alloys for structures, forgings and fasteners.

The big problems have been the forgeability and machinability of the tough alloys used in the intermediate elevated temperature applications. But they're being licked. Carpenter is now producing uniform elevated temperature alloys of very high quality which consistently meet tough aircraft specifications. Their quality and cleanness also allow tightened forging tolerances, improve machinability and cold forming properties. Result: More accurate forgings with better finishes . . . fewer rejects . . . faster production.

Complete information on application, fabrication and engineering properties of these alloys is summarized in our new booklet, "Carpenter Alloys for Elevated Temperature Service". For your copy, drop us a line on your Company letterhead. The Carpenter Steel Company, 135 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

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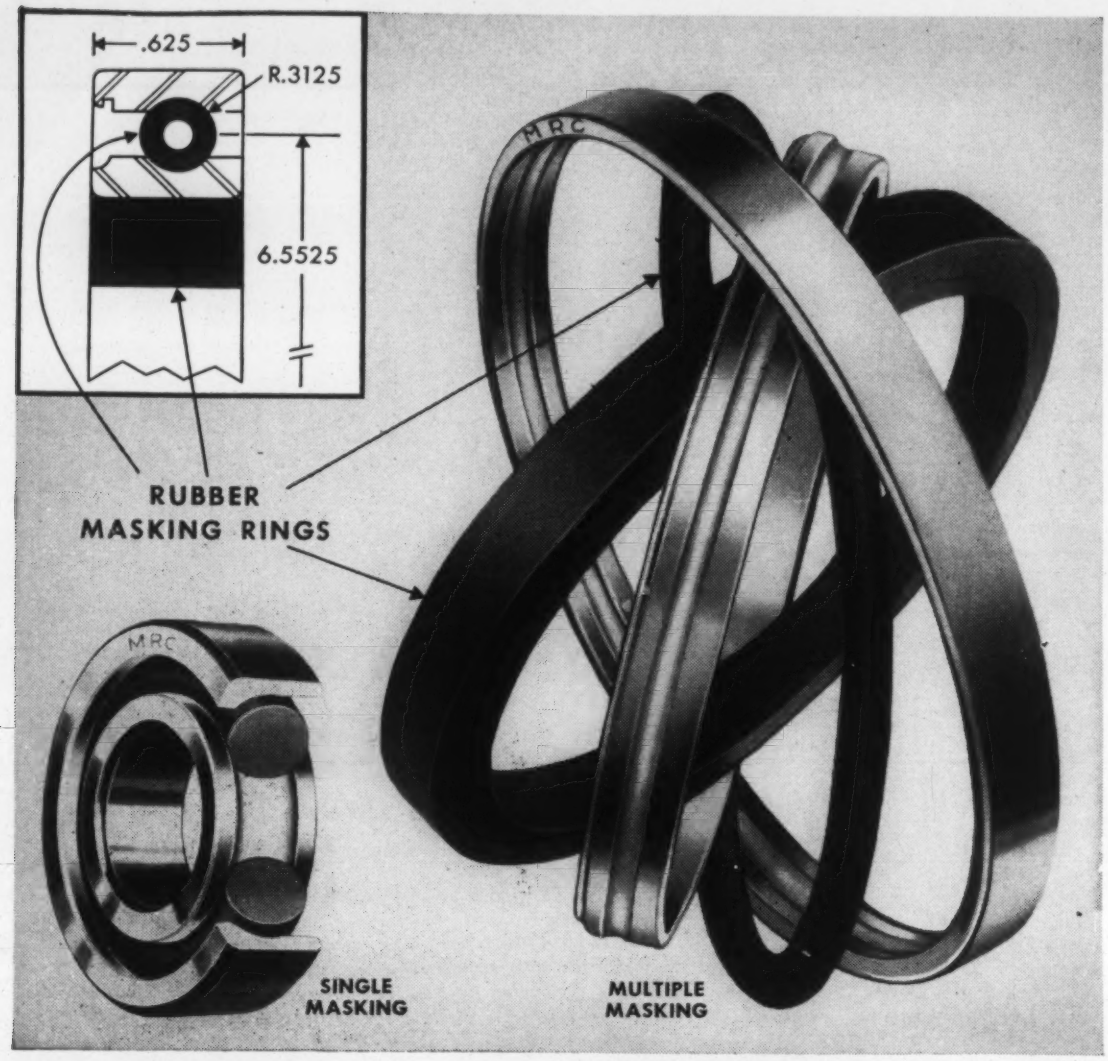

Photos courtesy Marlin-Rockwell Corp., Jamestown, N. Y.

Rubber Rings Mask Bearings during Plating Process

Here's a new way to mask out plating on bearing race grooves without tedious hand-labor. Regardless of bearing size, rubber rings are fitted precisely into ball grooves and inner ring bore so that plating can't sneak under the rubber even in torturous electroplating baths. Clean division lines always result. Inner ring and outer ring are held together so both can be plated simultaneously. This saves one complete plating cycle. And, this fast assembly prepares bearings for plating in seconds—eliminates costly hand-painting with unreliable stop-off lacquer.

These rubber rings are the result of Marlin-Rockwell Corporation (Jamestown, New York) consulting Continental to solve an important masking problem. Creative engineering successfully developed these extruded and spliced, or molded rubber rings which increased production 2000%—20 times faster than hand-painting. What's more, the special rubber compound withstands repeated baths in blistering acids and caustics without affecting precise dimensions, elasticity or resilience.

This rubber ring technique is typical of the thinking and ingenuity behind rubber parts by Continental. It also represents the economy and better end results accomplished by consulting a rubber specialist *during the planning stage* of a product. If you need help like this, call or write Continental —rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

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What's new IN MATERIALS

PRICE COMPARISON OF REINFORCING AGENTS

Agent →	Fabric	Mat	Flake
Glass Content by Wt, %.....	63	40	78
Reinforcement Price, $/lb.....	2.00	0.40	0.40
Raw Material Price, $/lb.....	1.40	0.40	0.50

of the woven laminates and is quite close in price to that of the mat laminate. Expected reduction of glass flake prices to 14¢ per lb will make a glass flake-reinforced plastics laminate the cheapest material from the viewpoint of material cost.

Arc Welding Process Is Fast, Economical

An improved arc welding process, developed by National Cylinder Gas Co., 840 N. Michigan Ave., Chicago 11, is intended primarily for single-pass horizontal and flat welding of mild steels, with or without scale, in thicknesses from 3/32 to 1/2 in.

The process, called Dual Shield, is claimed to "deposit weld metal 3 to 12 times faster than manual 'stick electrode' welding and a conservative 33% faster than established semiautomatic methods." Because of its almost complete elimination of spatter, the process is said to deposit more than 99% of its weld metal in the joint compared with 75 to 80% for manual welding.

How process works

Key to the effectiveness of the process is the addition of the following granular materials to the core of the welding wire: an ionizer to stabilize the electric arc; a deoxidizer to permit welding mill-run steel without removal of scale and other foreign matter; and a slag forming agent. Active carbon dioxide is used to exclude

OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

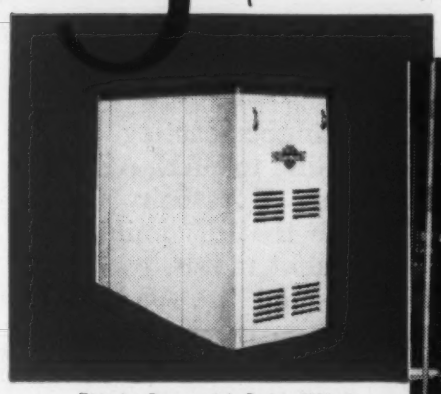
AMERICAN SMELTING AND REFINING COMPANY

Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

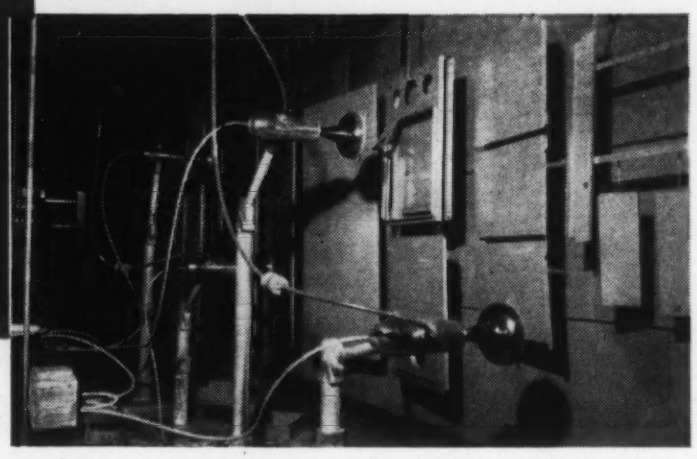
WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

For more information, turn to Reader Service card, circle No. 384

3 times as many Furnace Casings per gallon of paint with **RANSBURG NO. 2 PROCESS!**



This Lo Boy model, Series 6000, is typical of the Waterman-Waterbury line of winter air conditioners now painted electrostatically.



Quality of work is improved; Labor costs are cut and Production Stepped up 150% with RANSBURG Electrostatic Spray Painting

Results exceeded expectations when Waterman-Waterbury, Minneapolis, modernized their finishing department and went from hand spray to Ransburg No. 2 Process in painting their quality line of heating and air conditioning equipment.

By the former hand spray method, W-W used a half gallon of paint to coat a single casing. Now, with Ransburg No. 2, they get SIX CASINGS PER GALLON . . . or 3 times as many per gallon. Furnace casings, as well as other painted parts which go into the famous Waterbury Furnaces, now get a uniform coating of .8-mil.

Production was increased, too, as automatic painting enabled them to step up the conveyor speed from 7 fpm to 11½ fpm. Where they formerly turned out a complete furnace in five minutes, NOW they assemble three in just six minutes . . . an increase of 150%. All in all, they figure the modernization program—with Electro-Coating—saved over $11,000 in the first three months of operation.

NO REASON WHY YOU CAN'T DO IT TOO!

Whatever you paint, we'd like to tell you more about the efficiencies and worthwhile savings which can be yours with Ransburg Electro-Coating Processes. Get our No. 2 Process brochure which cites many on-the-job examples of electrostatic spray painting on a wide variety of products. Or, we'll be happy to loan you our new film, "The Big Attraction" which tells the electrostatic spray painting story in sound and full color.

Call or write

RANSBURG
Electro-Coating Corp.
Barth and Sanders, Indianapolis 7, Indiana

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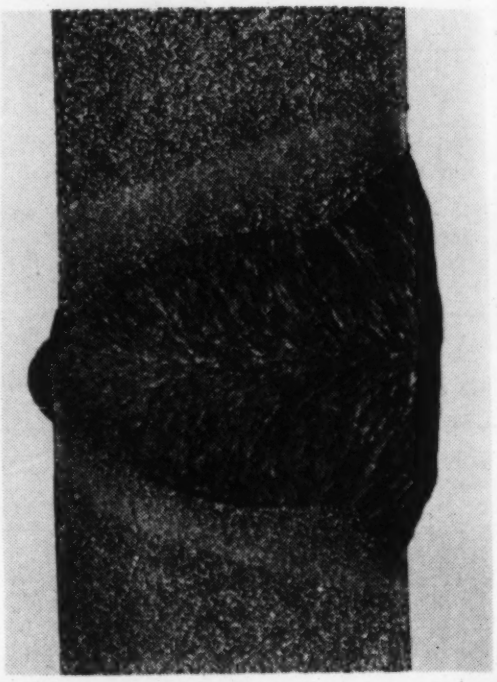
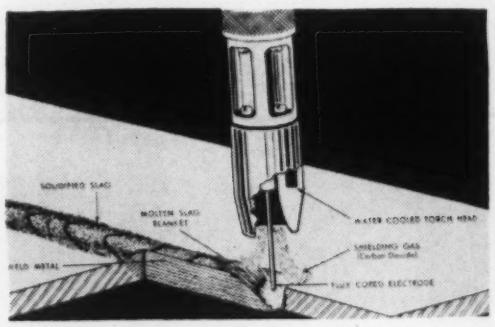
What's new IN MATERIALS



***Butt weld** in ⅝-in. mild steel shows penetration achieved by improved arc welding process.*



***Cutaway sketch** of Dual Shield arc welding process.*

contaminating air from the arc and to inject a measured portion of oxygen directly into the arc's path where it combines chemically with certain of the flux additives to clean and purify the metal being welded (see sketch). In addition, the technique is said to permit a welder to have the benefit of flux additives, yet see exactly what he is doing because the flux is inside the electrode.

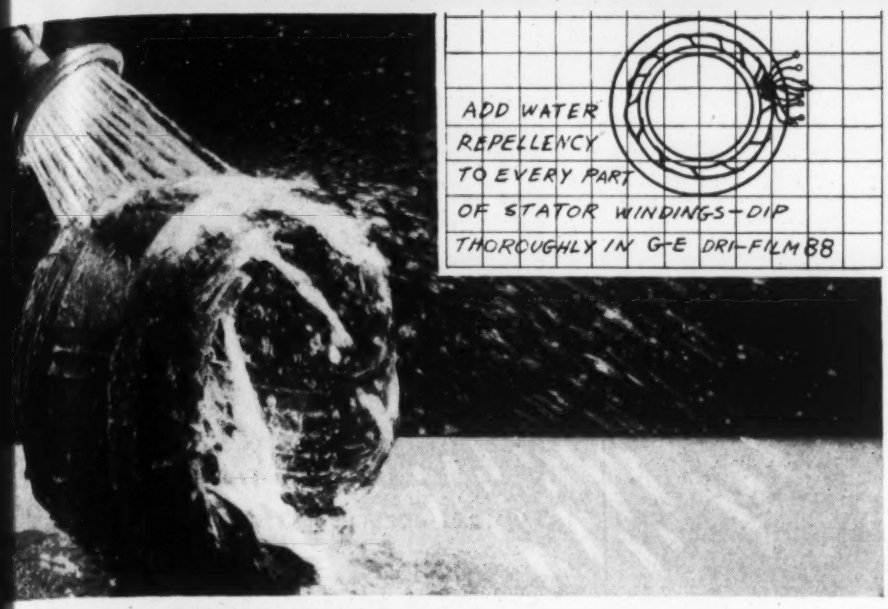
The Dual Shield arc is said to be a minimum of 1000 F hotter than the average 9000 F welding arc and produces a weld of 40% deeper penetration than manual processes. It will weld the full thickness of a ½-in. solid steel plate in a single pass.

(more What's New on p 168)

For more information, circle No. 517 ➤

HOW TO SOLVE ELECTRICAL EQUIPMENT DESIGN PROBLEMS WITH

GE SILICONE IDEAS



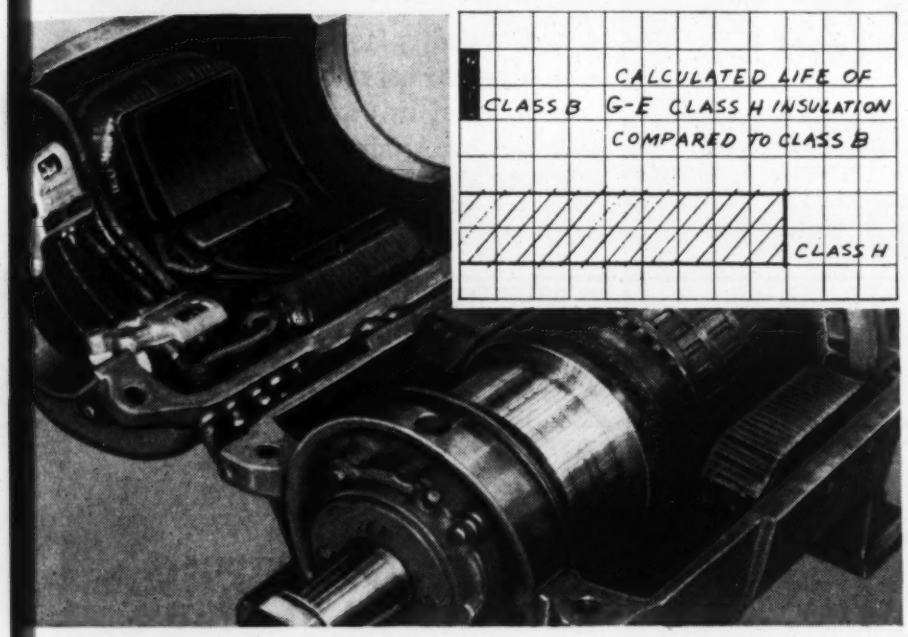
Problem: *Design a drip-proof motor which can be used in many areas normally requiring enclosed motors.*

Solution: Protect coils with G-E Silicone Dri-Film® 88.

Both electrical manufacturers and service shops are finding the application of G-E Dri-Film 88 an easy and inexpensive way to provide water repellency and a high-gloss finish for electrical coils.

Drip-proof motors with Dri-Film 88 protected coils are now being used in locations where more expensive enclosed motors were previously used. The benefits of water repellency can be added to equipment with relatively little increase in manufacturing cost since Dri-Film 88 resin can be applied to the coils by dipping and can be air-dried at room temperatures.

When you are designing motors, transformers, etc., Dri-Film 88 offers you a chance to improve your product at relatively low cost. When buying or specifying motors, this is a feature to look for.

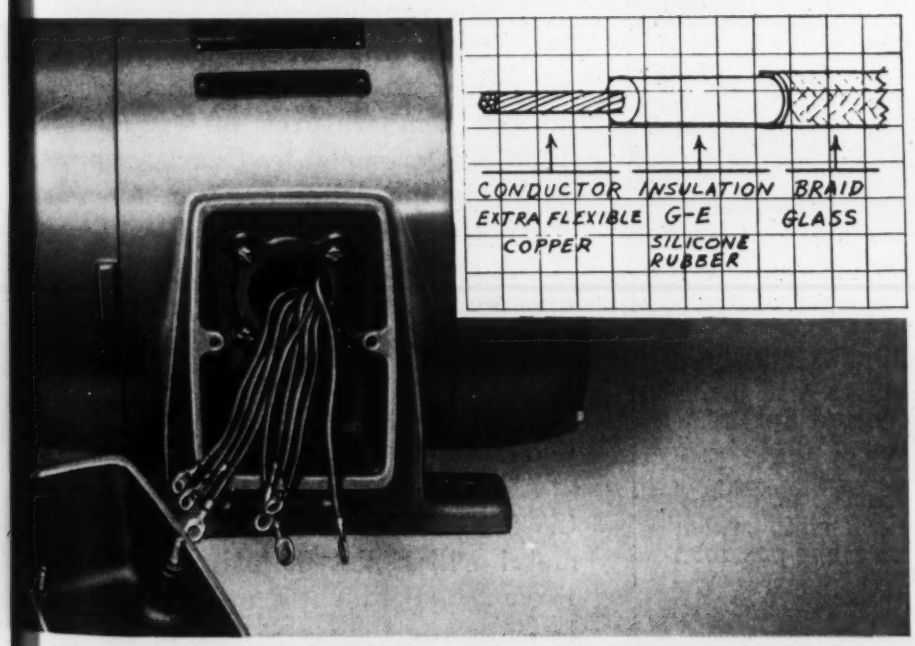


Problem: *Design a coil for DC motors that will eliminate insulation failure and increase normal operating life at least 10 times.*

Solution: Combine inorganic materials with G-E silicones in an improved insulation system.

Auxiliary mill motors often meet unexpected high ambient temperatures, unforeseen extra long duty or other emergency conditions—any of which can cause "roast-outs." This problem has been solved by a Class H G-E silicone insulation system which will withstand continuous high temperatures. Silicone-treated mica mat is used on commutating, exciting field and armature coils. In laboratory tests, this insulation has maintained full dielectric strength after 3½ months at 300°C.

Service life of this insulation has been calculated to be 32 times that of conventional Class B insulation. Actual tests with Class H and B motors coupled together prove that insulation with G-E silicones lasts more than 5 times as long. Five Class B motors have consecutively burned out; the Class H is still going strong.



Problem: *Eliminate a potential failure point, upgrade Class B equipment for temporary overloads.*

Solution: Lead wire insulated with G-E silicone rubber.

Silicone insulation, the standard for Class H equipment, enables manufacturers to make smaller, more compact motors, generators, and transformers. Class B equipment can also be upgraded to provide a safety margin for intermittent high temperature operation through the use of silicones. For example, silicone insulated lead wire eliminates a major source of failure in Class B motors, lets you standardize on one type of lead wire for both Class B and H equipment. Motor and apparatus lead wire made with G-E silicone rubber withstands moisture and has ozone resistance approaching that of mica. It is easy to strip and solder and is flexible at low temperatures.

If lead wire is a problem in your Class B equipment, it will pay you to look into General Electric silicone rubber.

MOTOR WEATHER-PROOFING

CLASS H DC MOTORS

APPARATUS LEAD WIRE

Mail this coupon for more information:

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

Section D2B9, Silicone Products Dept.
General Electric Company, Waterford, N. Y.

Send me application data on G-E silicone ☐ Dri-Film 88
☐ Class H insulation ☐ Lead wire, including list of suppliers.

Name_____ **Title**_____

Company_____

Address_____

City **Zone** **State**

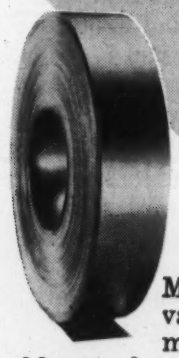
CMP

RESTRICTED SPECIFICATION COLD ROLLED STRIP STEEL

SIZE	8 x .045
ANALYSIS	1010
FINISH	#2 finish
HARDNESS	Non-Scalloping quality
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	250# per inch of width
PACKAGING	Skidded

SIZE	12 x .032
ANALYSIS	1010
FINISH	#3 finish
HARDNESS	#4 Temper
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	up to 200# per inch of width
PACKAGING	Paper inter-leaved—skidded and shrouded

Serves Typical Low Carbon End Use Requirements Such as these . .



SIZE	4 x .065
ANALYSIS	1010
FINISH	#2 finish
HARDNESS	#3 Temper
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	Cut lengths
PACKAGING	Skidded

Many times, by varying processing methods, CMP is able to develop properties in cold rolled strip steel which greatly facilitate production operations and/or give the product superior qualities without adding to end product cost. End result is lower costs through improved products or better assembly and improved yield.

We believe you will find it worthwhile to investigate the possibilities of CMP Restricted Specification Cold Rolled Strip Steel applied to your production.

CMP PRODUCTS

Low Carbon, High Carbon — Annealed or Tempered, Stainless, Alloy, Electro Zinc Coated.

THE 3 IN 1 SOURCE FOR YOUR COLD ROLLED STRIP STEEL

Now there are three CMP plants with facilities for production of "Restricted Specification" cold rolled strip. Strategic locations at Youngstown, Indianapolis and Los Angeles, provide the security of 3 sources of supply plus the close working relationship which these local production centers make possible.

CMP

THE COLD METAL PRODUCTS CO.
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, INDIANAPOLIS AND LOS ANGELES
SALES OFFICES: NEW YORK - CLEVELAND - DETROIT - INDIANAPOLIS
CHICAGO - LOS ANGELES - SAN FRANCISCO

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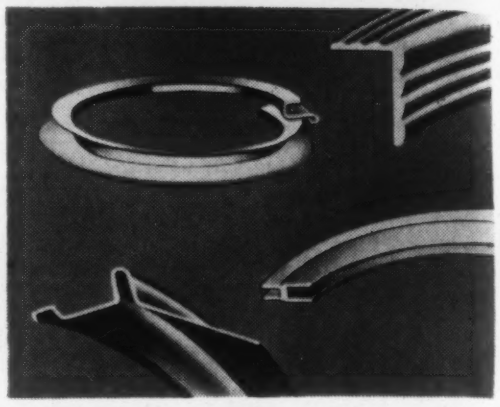
What's new IN MATERIALS



***Typical** curved extrusions.*

Curved Extrusions

Curved plastics extrusions in circles or sections of circles of 4 in. dia. upward are being marketed by Anchor Plastics Co., Inc., 36-36 36th St., Long Island City 6, N. Y. The company produces the curved plastics moldings with a patented technique called the "Curved Extrusion Process" that is said to eliminate postforming of thermoplastic materials.

Refractory Cement Holds Well at –420 F

A new refractory cement, capable of bonding metal, glass and ceramics to metal, withstands service temperatures of –420 to 1000 F. Developed by Charles Engelhard, Inc., 850 Passaic Ave., East Newark, N. J., and called CA-9, the material is composed of ground phlogopite, a polysiloxane polymer, and refractory oxides. The cement is said to age well, and is waterproof, nonhydroscopic and resistant to most chemicals.

According to the producer, a CA-9 joint between two pieces of metal will resist 80 psi of shear force at 900 F. The cement is said to be unaffected by 15 min of 45G vibration through a 1-in. double amplitude at 1500 cps. Wires embedded in the cement are not shorted when immersed in water.

Since the material remains slightly malleable after drying, it

How CAMPCO ACETATE adds see-level ...buy-level... sales appeal

*

When customers can see . . . they buy. And when your blister packs are made of CAMPCO acetate, they're sparkling clear—yet surprisingly strong, even in thinner gauges.

For example: the fish lure you see above. What better way way to display lures—yet protect the hooks? . . . And what better way than those shown below at right, to package small hardware? . . . Or, notice the sample pill pack. It carries its own professional sales message, built right in.

CAMPCO acetate makes see-level packaging and selling possible at unusually low cost. It's easy to form, won't cloud or discolor because of CAMPCO's special non-blushing formulation, and is ideal for short runs or long. Also, combining it with liners or package bottoms made of CAMPCO "Registrite" sheet makes an attractive merchandiser such as the Thimble Drome package by L. M. Cox Mfg. Co., Inc., Santa Ana, Calif. (shown directly below). This rubber modified styrene sheet comes in glossy or mat finish plus a variety of designs ranging from woodgrains to polka dots. Most gauges and finishes available immediately from stock.

But whether it's pills or toys—acetate, butyrate, or styrene—it pays to use CAMPCO sheet and film. They'll put real see-level in your packages. For details, write:

CAMPCO *sheet and film* *a division of*

Chicago Molded Products Corp., 2722 Normandy Ave., Chicago 35, Illinois

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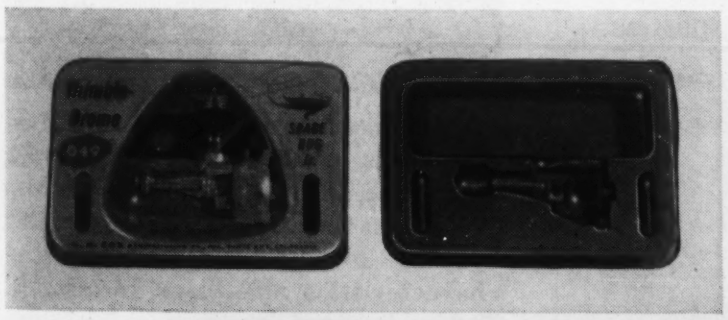


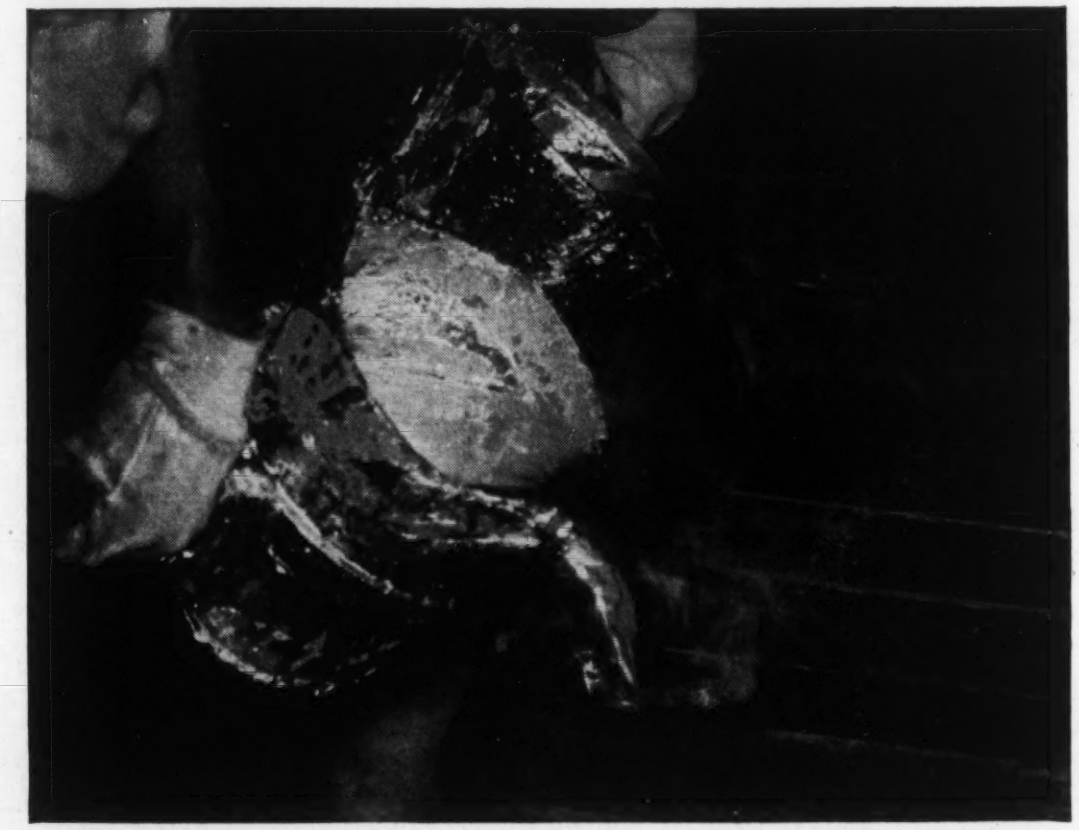
*

*

*These packages manufactured by Plastic Container Div. of Plastofilm Inc., Wheaton, Ill.

For more information, turn to Reader Service card, circle No. 408

Do you hear meaningless claims when you buy self-aging Aluminum Alloys?



Federated Tenzaloy is the most widely used of all high-strength, self-aging aluminum alloys because it has the highest yield strength, and it has the best all-around combination of properties. Yield strength is the true measure of a metal's ability to take punishment, regardless of other claims that are made.

When you buy Federated Tenzaloy, you can be sure it will perform as well as its specifications indicate. Tenzaloy is produced under the strictest quality-control procedures, developed by ASARCO's Central Research Laboratory, where refining and testing techniques control impurities to parts per million, if required.

Hundreds of foundries and manufacturers use Tenzaloy when castings with superior properties are desired — and to replace ordinary alloys which require additional operations to meet required properties.

Why not ask your Federated field man to tell you who uses this metal and how? He will be around to see you soon, and it will benefit you to talk to him.

Federated Metals

ASARCO

Division of

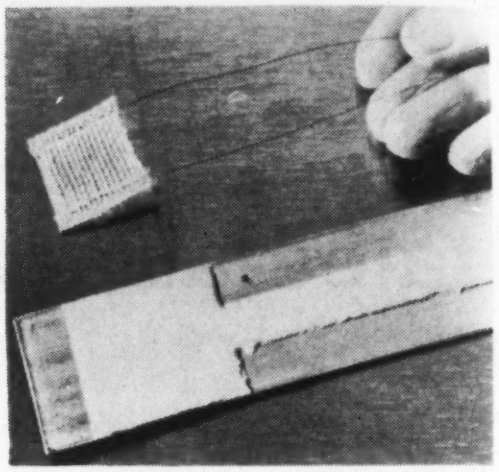
AMERICAN SMELTING AND REFINING COMPANY

120 Broadway • New York 5, N.Y.

In Canada: Federated Metals Canada, Ltd., Toronto and Montreal

For more information, turn to Reader Service card, circle No. 429

What's new IN MATERIALS

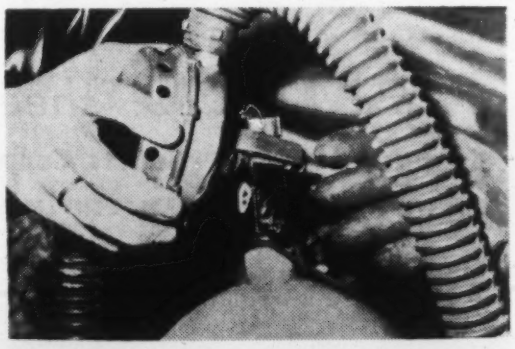


Heat measuring instrument *is glued to part of a guided missile skin with new refractory cement.*

will not crack, craze or check when used on a constantly flexing surface, or when used to join materials with different thermal expansion coefficients.

The new cement is recommended for attaching surface temperature transducers, strain gages and lead wires to the skins of guided missiles. Another potential application for the cement may be in the repair of small electric furnaces.

(more What's New on p 173)



Plastics valve parts—Three plastics parts used in an air cylinder valve help supply air to skin divers. Nylon is used as the valve seat because of its excellent sealing characteristics and wear resistance. Teflon is used as a packing ring because of its low coefficient of friction and excellent sealing characteristics. An external Teflon gasket surrounds the outlet port, permitting a positive and easily operated seal between the outlet yoke and the valve body.

For more information, circle No. 561

What's new IN MATERIALS

Clear Polyester Film for Light Packaging

A new polyester film especially suitable for light packaging jobs where moisture, oil and odor retention is required has been announced by Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul, Minn. The film, Scotchpak No. 10A3, is a clear film that is heat sealable on one side.

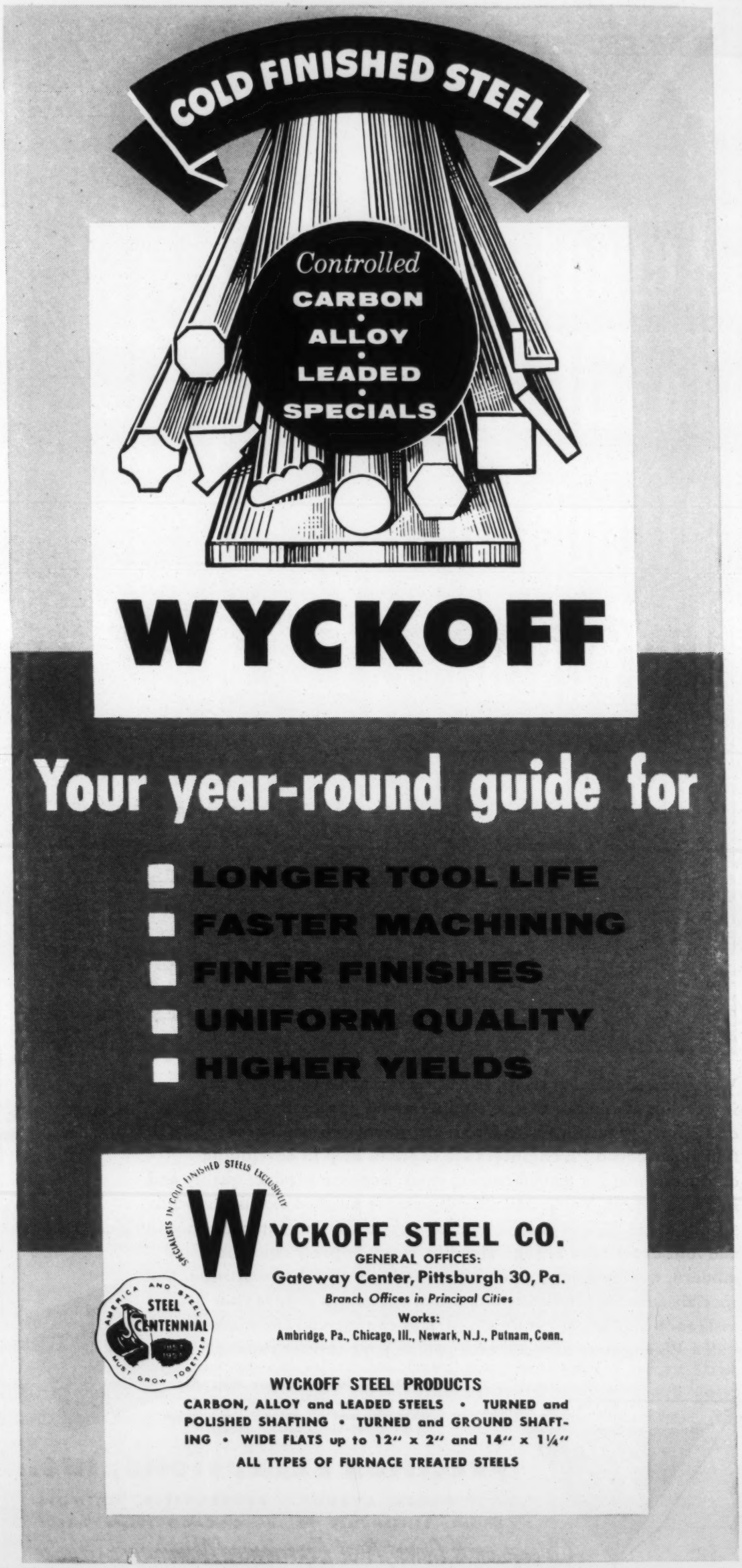
The material has a tensile strength of 10,000 psi, an elongation of 200%, a burst strength (Mullen test) of 32 psi, and an air permeability of 5.2 gm/100 sq in./42 hr. According to the producer, the film retains its properties over a temperature range of –70 to above 230 F.

The polyester film can be laminated to paper without heat damage to the paper, and the protected paper can be written on with a wax pencil for identification purposes. The film is presently available in widths up to 19 in. and in roll lengths of 1500 yd.

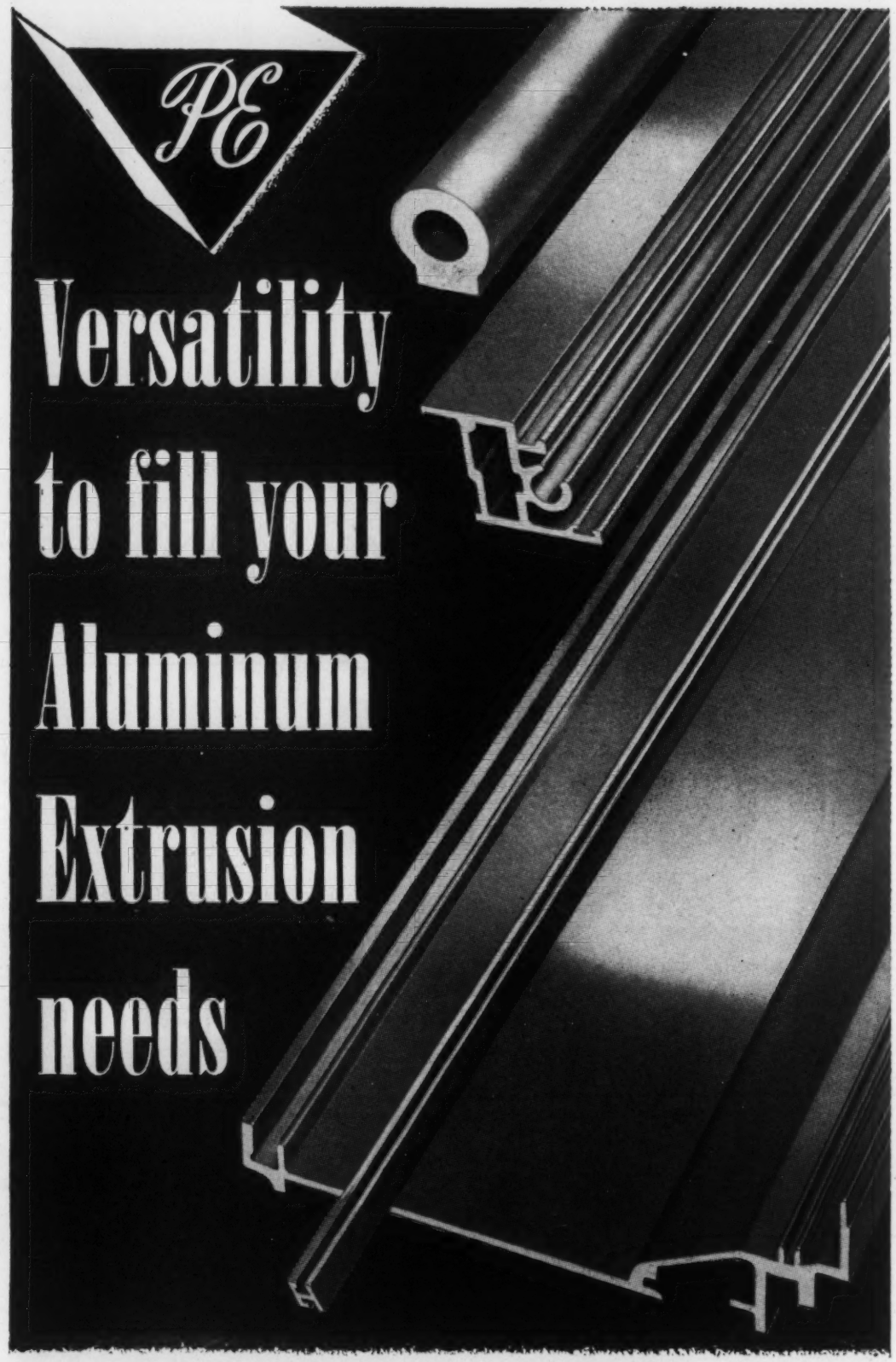
Chromium, SAP Types Promising for Future

Some hope that chromium-base high temperature alloys may be suitable for aircraft and other castings was held out by Nicholas J. Grant of Massachusetts Institute of Technology in a talk given at the spring technical meeting of the Investment Casting Institute in Washington. Mr. Grant revealed that alloying of chromium may lower the melting point of high temperature alloys sufficiently to make casting possible. The speaker revealed that alloys containing 40 to 60% chromium can be readily cast, although the 60% chromium-base alloys, which must be poured at temperatures of 3300 to 3400 F, are quite hard on investment materials.

In surveying other materials for high temperature aircraft ap-



For more information, turn to Reader Service card, circle No. 433



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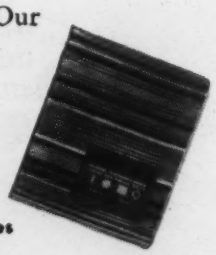

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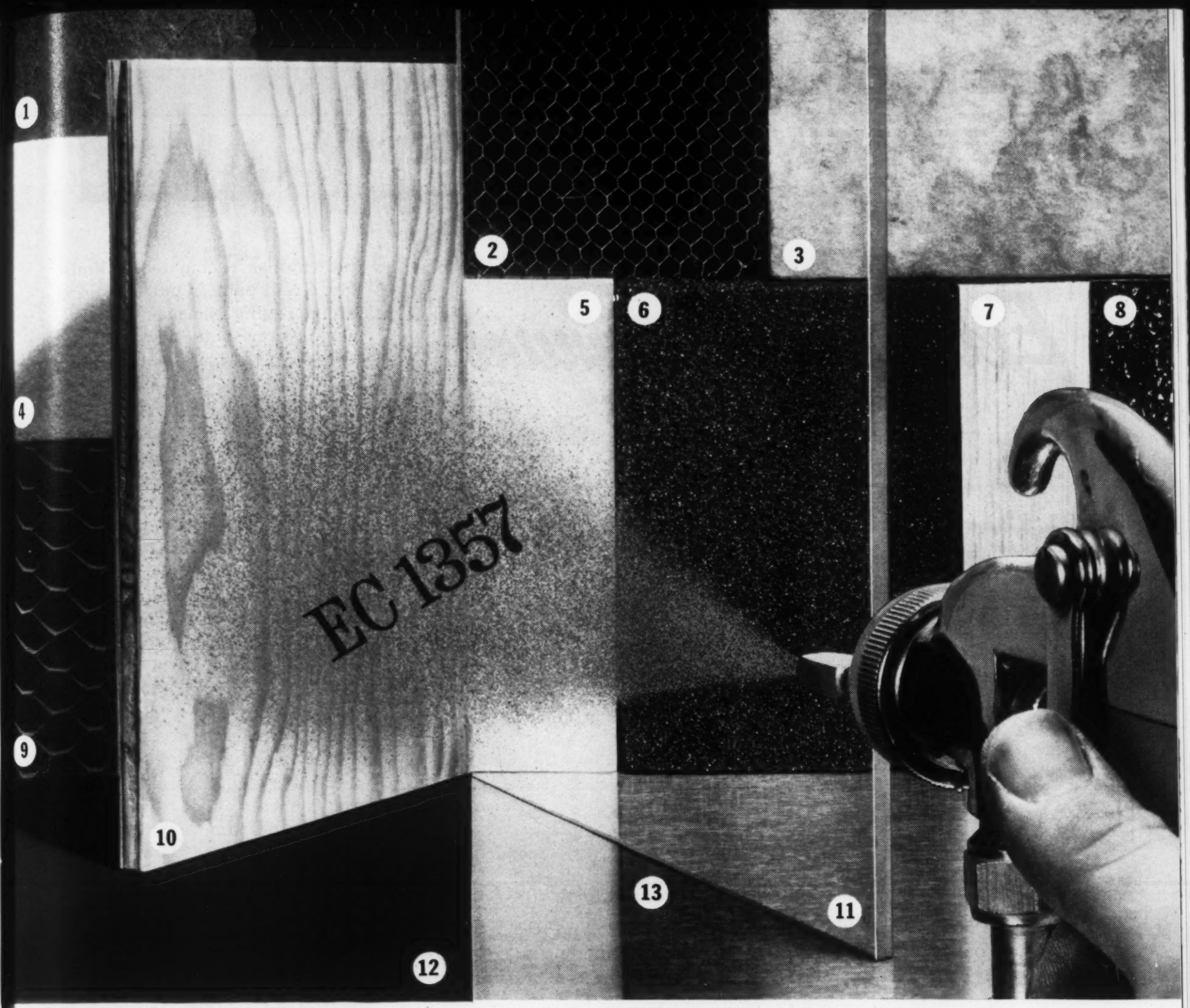
plications, Mr. Grant, for the most part, summarized the results of an earlier symposium on high temperature materials. The speaker cited the following requirements for two critical aircraft parts: 1) blades must withstand a minimum stress of 20,000 psi at 800 F and have a minimum life of 100 hr; 2) vanes must withstand a stress of 3000 to 5000 psi at 2100 F, must have good thermal shock resistance and must resist high thermal stresses. Currently being sought are materials that will meet these requirements at a cost on the order of $10 to $20 per lb.

Nickel-base alloys

The speaker revealed that there is some hope that nickel-base alloys can be modified for use up to 1800 F. He stated that Inco 13, containing 5% aluminum, is particularly promising at this time. There is also hope for cobalt-base alloys as blade materials. Mr. Grant said that cobalt alloys might be much further in their development had the amount of research spent on them during the past seven or eight years approached that spent on nickel. Unlike molybdenum, cobalt, although it has poor oxidation resistance at high temperatures, does not form a liquid volatile oxide. Hence there is no danger of the catastrophic oxidation that can occur with molybdenum if the coating fails. This is another reason why Mr. Grant appears to believe that much more work with cobalt-base alloys is warranted.

The high density of tungsten is a well known limitation of tungsten-base alloys for high temperature applications. However, Mr. Grant pointed out that another limitation of this alloy is its lack of outstanding oxidation resistance. Not much work has been done on alloying tungsten to provide greater oxidation resistance, he said.

The usefulness of cermets in



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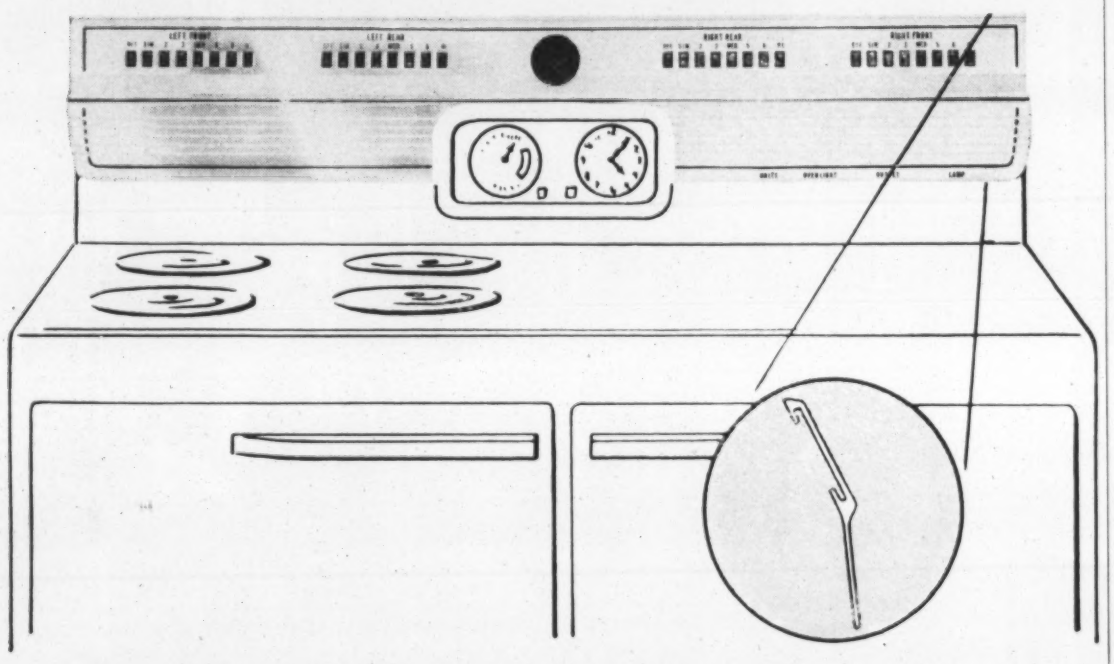

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For more information, turn to Reader Service card, circle No. 431

jet engines seems to be limited. Mr. Grant pointed out that no way of improving the poor impact resistance at both low and high temperatures has yet been found.

SAP materials

Perhaps the most promising development currently under way in the field of high temperature materials is the development of SAP-type materials. Especially promising is a material consisting of nickel plus fine particles of aluminum oxide. The secret of the greatly increased strength of these materials is "fine interparticle spacing," i.e., spacing of particles on the order of 0.2 to 0.3 micron.

Other talks given during the technical session included: engineering properties of pattern waxes; new techniques for nonferrous precision castings; and requirements of investment casting for airframe applications.

Steel To Be Clad with Titanium, Zirconium

Steady progress toward the production of titanium, zirconium and the Hastelloys in the form of clad steel plates is being made at Lukens Steel Co.

Potential applications of such clad metals are many and varied. Some of them involve processes of a classified nature. But, according to Eugene M. Smith, Lukens research administrator, "zirconium-clad, for example, would have a number of atomic applications. Hastelloy-clads would have a number of applications in various petrochemical processes and titanium-clads would be applicable in acid processes and for service involving chlorides."

Plastisol Compounds

A series of rigid plastisol compounds, known as Rigidsol, has been introduced by Watson-Stand-

"You can form dies 4 times faster with Formica S-52 die stock"

S-52 aircraft die used by Twin Coach Corp. for forming this beaded skin airplane wing part. It is machined to a tolerance of .005" and can easily be lifted by one man.

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"Twin Coach has been using Formica S-52 laminated plastics for over four years now, for pressing aircraft and coach parts. It's the most economical material we've ever used for this purpose.

"S-52 is easier to machine to close tolerances. It has a hard, dense structure that holds its shape. And its smooth surface never puts a pattern in the metal being formed."

Manufacturers interested in better, faster and cheaper forming of non-ferrous metal, plastic, wood, rubber, vulcanized fibre and other ductile materials — should check Formica S-52. Send today for your free copy of bulletin 604. Formica Corporation, subsidiary of American Cyanamid, 4550-7 Spring Grove Ave., Cincinnati 32, Ohio.

S-52 8 ways better than steel dies:

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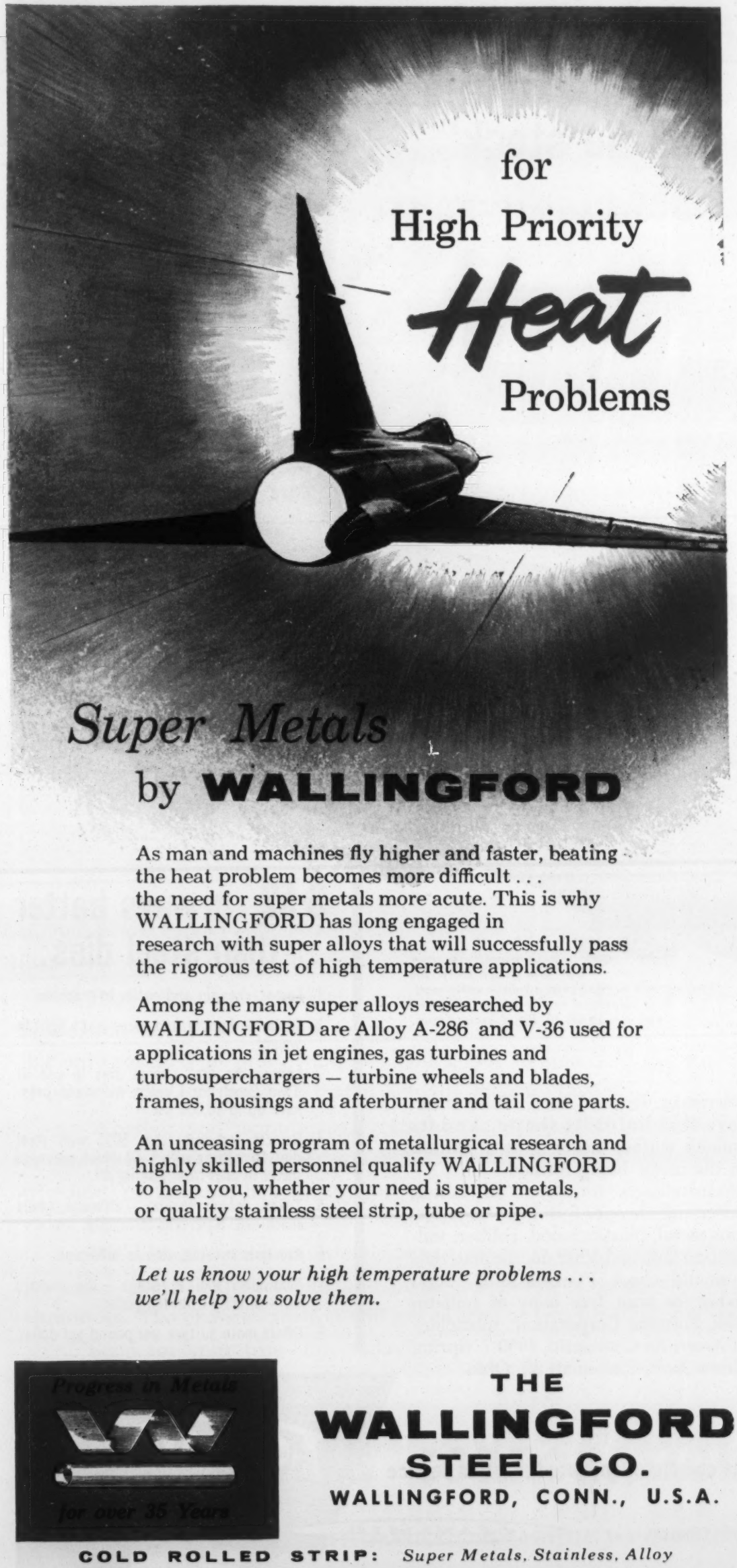

As man and machines fly higher and faster, beating the heat problem becomes more difficult . . . the need for super metals more acute. This is why WALLINGFORD has long engaged in research with super alloys that will successfully pass the rigorous test of high temperature applications.

Among the many super alloys researched by WALLINGFORD are Alloy A-286 and V-36 used for applications in jet engines, gas turbines and turbosuperchargers — turbine wheels and blades, frames, housings and afterburner and tail cone parts.

An unceasing program of metallurgical research and highly skilled personnel qualify WALLINGFORD to help you, whether your need is super metals, or quality stainless steel strip, tube or pipe.

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ard Co., 217 Galveston Ave., Pittsburgh 30, Pa. The compounds are low plasticized vinyl dispersions that, upon heating to 400 F, are converted to a tough, rigid, nonbrittle elastomer. The compounds are said to maintain excellent viscosity stability on aging, and can be used in rotational and slush molding, spread coating and casting applications.

Products presently produced with the vinyl dispersions include anatomical models, boat bumpers, battery water jugs, toys and advertising displays.

Russians Develop Shot Peening Test

A new, nondestructive test method for checking the effectiveness of shot peening has been developed in Russia. A discussion of the new method is given by Petrova and Shashin in the Nov '56 issue of *Vestnik Mashinostroyeniya* (Russian). The method, based on the change in electrical and magnetic properties caused by plastic deformation of the surface layer of steel, is said to be a satisfactory control method as well as a suitable means of determining the depth of the cold-worked layer in finished steel parts.

Since shot peening is generally used to improve fatigue properties, the only logical means of checking its effectiveness seems to be fatigue tests. However, fatigue tests are destructive and are an impractical means of controlling production. Microhardness and x-ray tests are also destructive and can be used only on soft materials.

With the new test method, fatigue and other tests do not need to be run to select optimum shot peening conditions. With the new method, shot peening conditions can be determined purely on the basis of the depth of the layer

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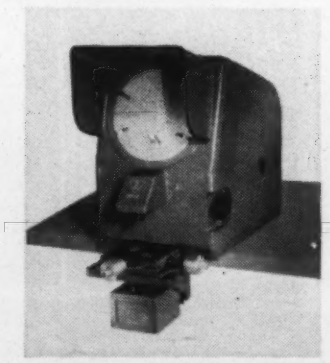

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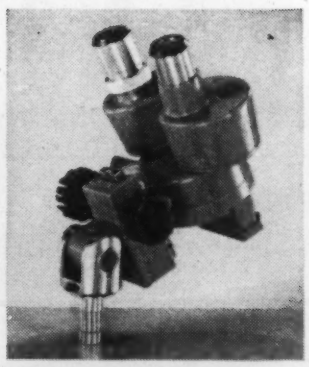

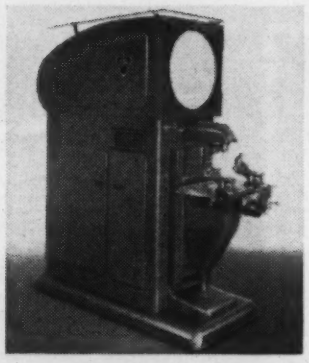

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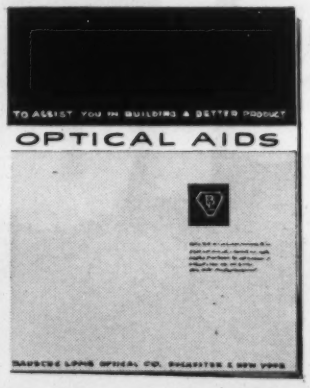

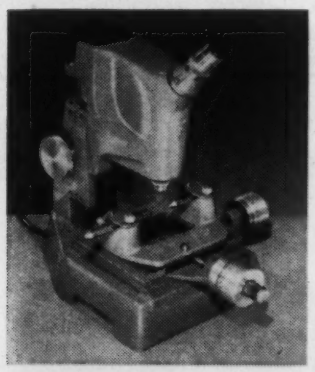

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cold worked by shot peening. Maximum depth values obtained with the new method are about the same as values obtained with destructive fatigue tests.

Aluminum Stair Tread Is Light, Slip-Proof

A die cast aluminum stair tread which combines safer footing with long-term maintenance savings is being produced by Aluminum Co. of America.

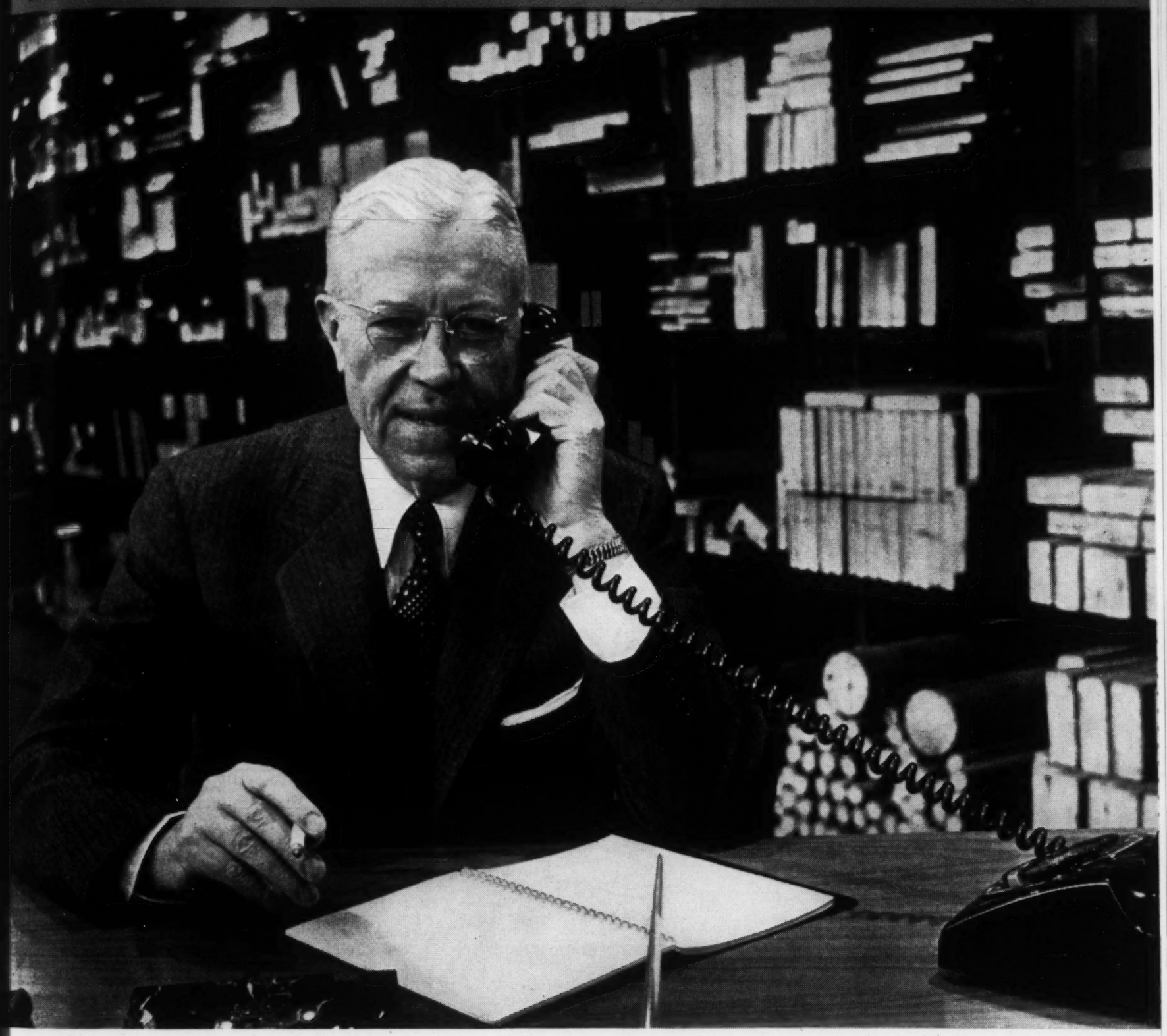
Designed for use in industries where stairs are subject to extreme weathering or corrosive atmospheres, the aluminum die cast tread utilizes a fused aluminum oxide abrasive metallurgically bonded to the aluminum plate to provide a rough, slip-proof front surface. Because the grating is cast in one piece, concentrated loads are distributed more evenly over all bearing bars. Though designed to carry the weight of a heavy man, the stair has withstood loads in excess of 3000 lb. Deflection and permanent set are less than in comparable conventional treads.

Three finishes are available: 1) for standard structural purposes, the "as fabricated" surface is suggested. Casting "flash" and gates are trimmed to within 1/32

***Die cast aluminum** stair tread provides safer footing, cuts maintenance.*

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corp.



For Answers to Tool Steel Problems

CHECK WITH YOUR BETHLEHEM DISTRIBUTOR

Virtually every business day you are faced with a question or two about tool steel. On occasion the solution is relatively easy, such as ironing out some detail about delivery. But often it can be considerably more complex—perhaps weighing the merits of two similar grades, or determining the proper cycle of heat-treatment to obtain a more effective die life.

Whatever the problem, it calls for expert opinion, and that's where your Bethlehem tool steel distributor comes in. For he's a specialist in tool steel matters, and it's part of his job to see that your questions are answered promptly and courteously. Besides, he can also save you time when you need tool steel, for his diversified stocks are ready to go at a moment's notice. Make it a point to check with your Bethlehem distributor often. It will take but a few minutes at most, and it's one of the wisest moves you can make.

BETHLEHEM STEEL

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JOB

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or
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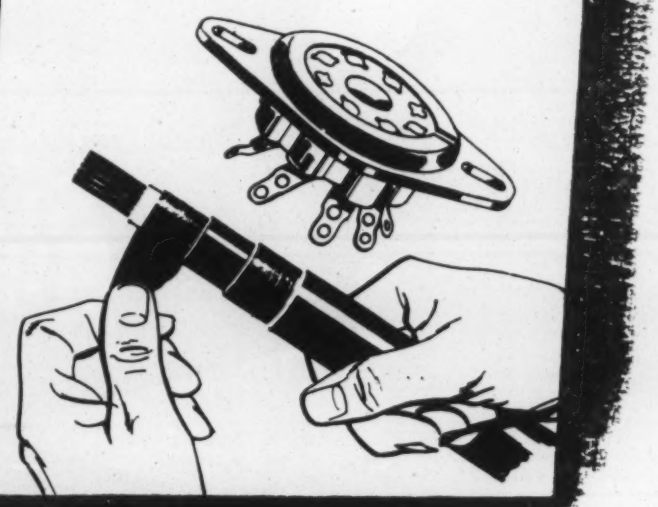
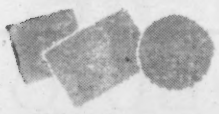


Tag Stocks



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East Walpole, Massachusetts

MANUFACTURERS OF TECHNICAL AND INDUSTRIAL PAPERS

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What's new IN MATERIALS

in. 2) For sanitary stairways in packing plants, bakeries, dairies, breweries and other food processing plants the "polished finish" is recommended. Tread surface is belt sanded, nosing is hand polished and a clear lacquer is applied to prevent tarnishing. 3) For outside applications, such as on shipboard where treads are subject to sea water immersion and spray, a "marine finish" is applied. This is an anodized surface covered with a thin coat of aluminum paint. Anodizing provides maximum corrosion and abrasion resistance.

Silicone Rubber Coating Resists Softening

Union Carbide Corp., Silicones Div., 30 E. 42nd St., New York 17, has announced the availability of K-1014 silicone rubber compound for use as a basic stock for solvent coating solutions. The material can also be used as a low durometer, general purpose molding compound. According to the producer, its features include good electrical properties and resistance to reversion (softening), combined with the ability to easily form solvent coating solutions. Glass fabrics coated with this silicone rubber are said to meet all requirements of Navy Shipboard Spec MIL-C-2194B.

The silicone rubber compound is available as either a 100% silicone solids low durometer compound or as a 35% silicone solids (in toluene) coating solution. Both the compound and coating solution

PROPERTIES OF K-1014[a]

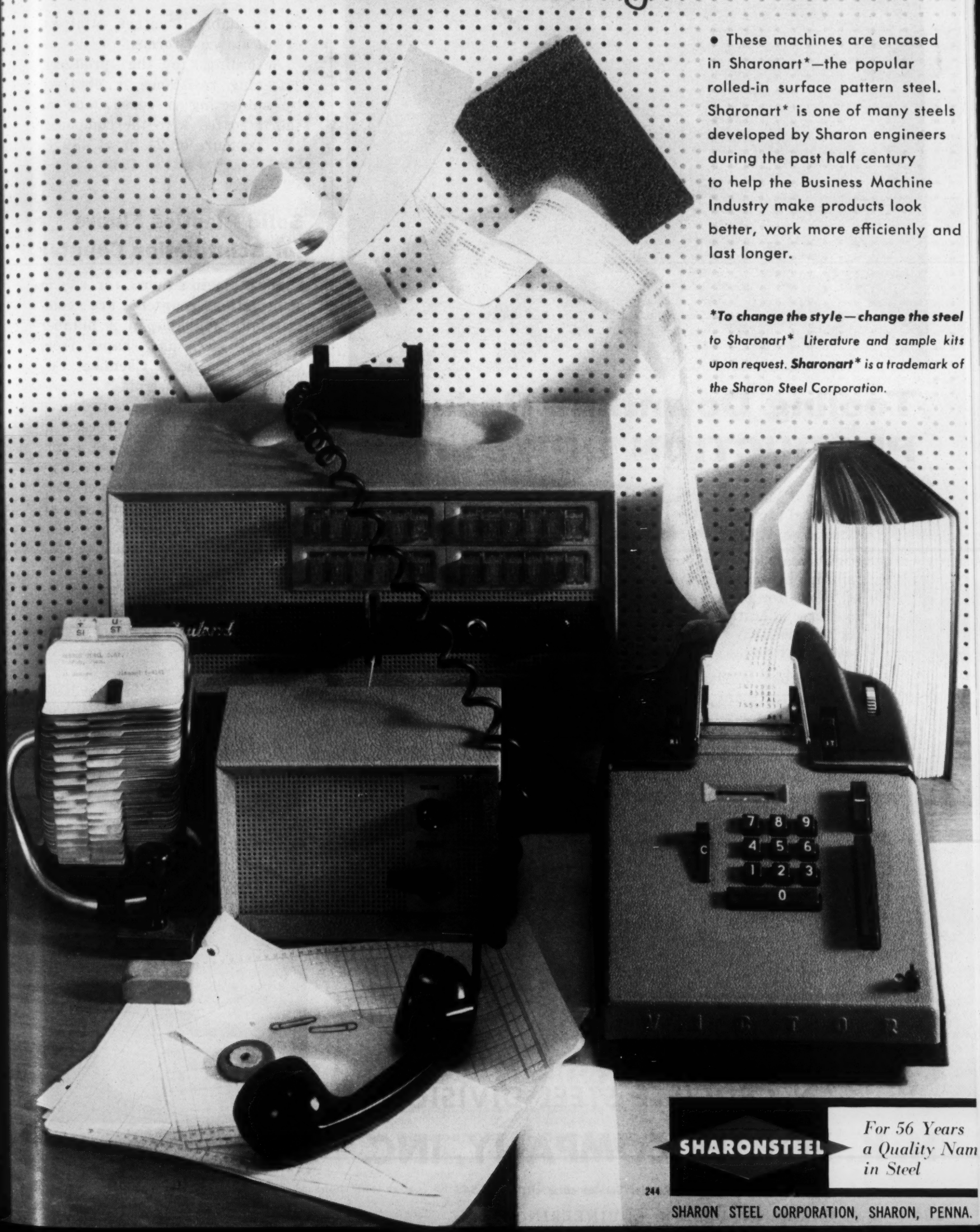
Tensile Strength, psi	520
Elongation, %	500
Tear Strength, lb/in.	60
Durometer Hardness	A 40
Specific Gravity	1.36

[a]Oven cured 24 hr at 480 F.

For more information, circle No. 459 ➤

IN BUSINESS MACHINES, TOO,

Sharonsteel Quality STANDS OUT



• These machines are encased in Sharonart*—the popular rolled-in surface pattern steel. Sharonart* is one of many steels developed by Sharon engineers during the past half century to help the Business Machine Industry make products look better, work more efficiently and last longer.

To change the style—change the steel** to Sharonart* Literature and sample kits upon request. **Sharonart is a trademark of the Sharon Steel Corporation.

SHARONSTEEL

For 56 Years a Quality Nam in Steel

244

SHARON STEEL CORPORATION, SHARON, PENNA.

Proof of Vulcan Tool Steel Superiority:

Tooling Downtime Reduced PRODUCTION UP 15%!

Vulcan TM-6, "M-2 type" high-speed tool steel, has increased tap life by 15% at Detroit Brass & Malleable Company, Wyandotte, Michigan.

Eight years of closely-controlled "stand up" tests of milling cutters and thread hobs preceded the selection of TM-6 for exclusive use in threading and tapping machine operations. *The payoff:* Production records, for the past seven years, offer positive proof of 15% better performance by using Vulcan TM-6.

Comparable on-the-job performance information is available for many of Vulcan's other steel grades. For the name of your nearest Vulcan representative write, wire or call collect. Vulcan Crucible Steel Division, H. K. Porter Company, Inc., Aliquippa, Pa.

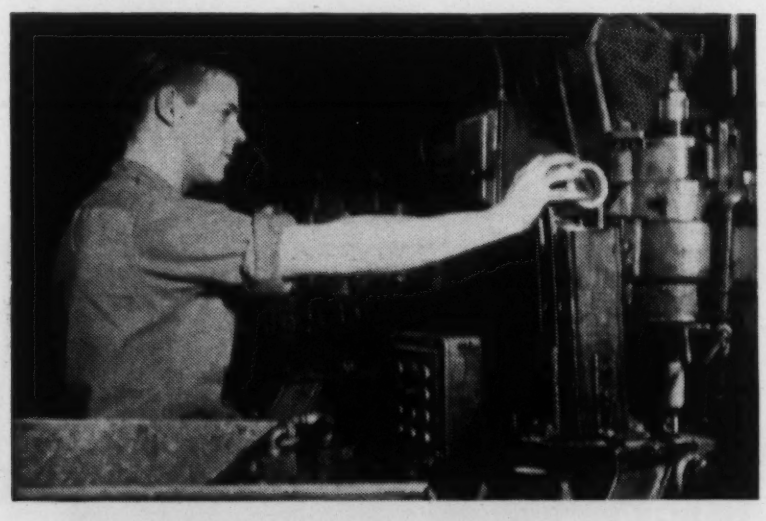


Photo at top shows General Foreman Robert Welch giving "specification plus" okay to DBM fittings as Vulcan representative examines tap used in manufacture.

Photo at left shows typical tapping machine operation at Detroit Brass & Malleable Company's nine-acre site.

VULCAN CRUCIBLE STEEL DIVISION

H. K. PORTER COMPANY, INC.

For more information, turn to Reader Service card, circle No. 543

What's new IN MATERIALS

are available in either catalyzed or uncatalyzed forms.

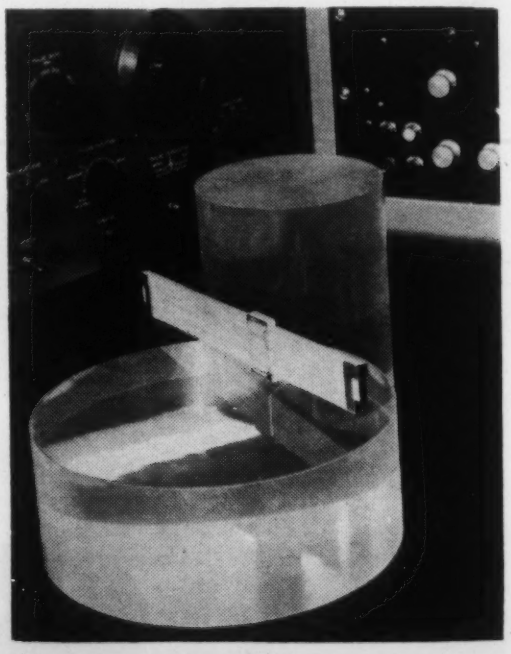
According to the producer, softening resistance is obtained by subjecting a cured tape or fabric coated with the compound to a postcure of 24 hr at 480 F.

Solid Plastics Fluors for Scintillation Counter

Solid plastics fluors for use in scintillation counters are commercially available in a number of large sizes and shapes from Cadillac Plastic & Chemical Co., 15111 2nd St., Detroit 3.

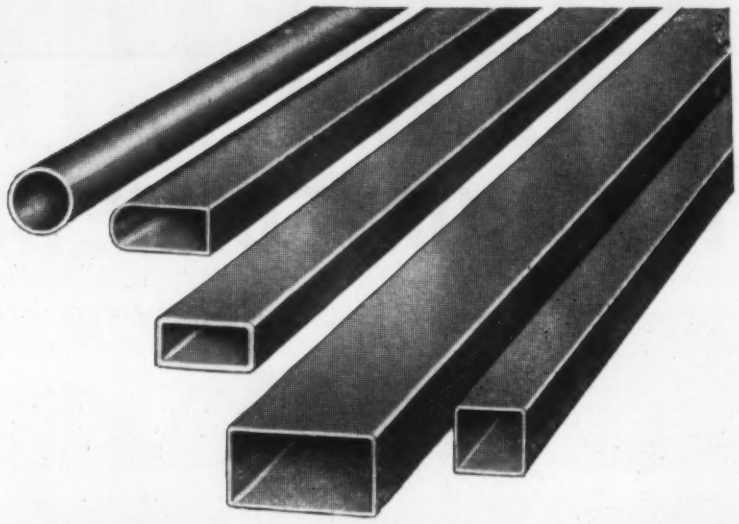
The plastics fluors are produced by a special casting process in which small percentages of p-terphenyl and tetraphenylbutadiene are incorporated in a pure styrene base. Ionizing radiations falling upon the styrene alloy are converted into a light pulse in the ultraviolet spectrum. This energy is absorved by the tetraphenylbutadiene and re-emitted as a pulse in the blue portion of the spectrum visible to a photo-multiplier cell.

Plastics fluors are said to have good scintillation characteristics and to be superior to commonly



***Large plastics fluor** is used in cosmic ray measurements.*

Another Plus . . . from **Brainard**



Tubing:

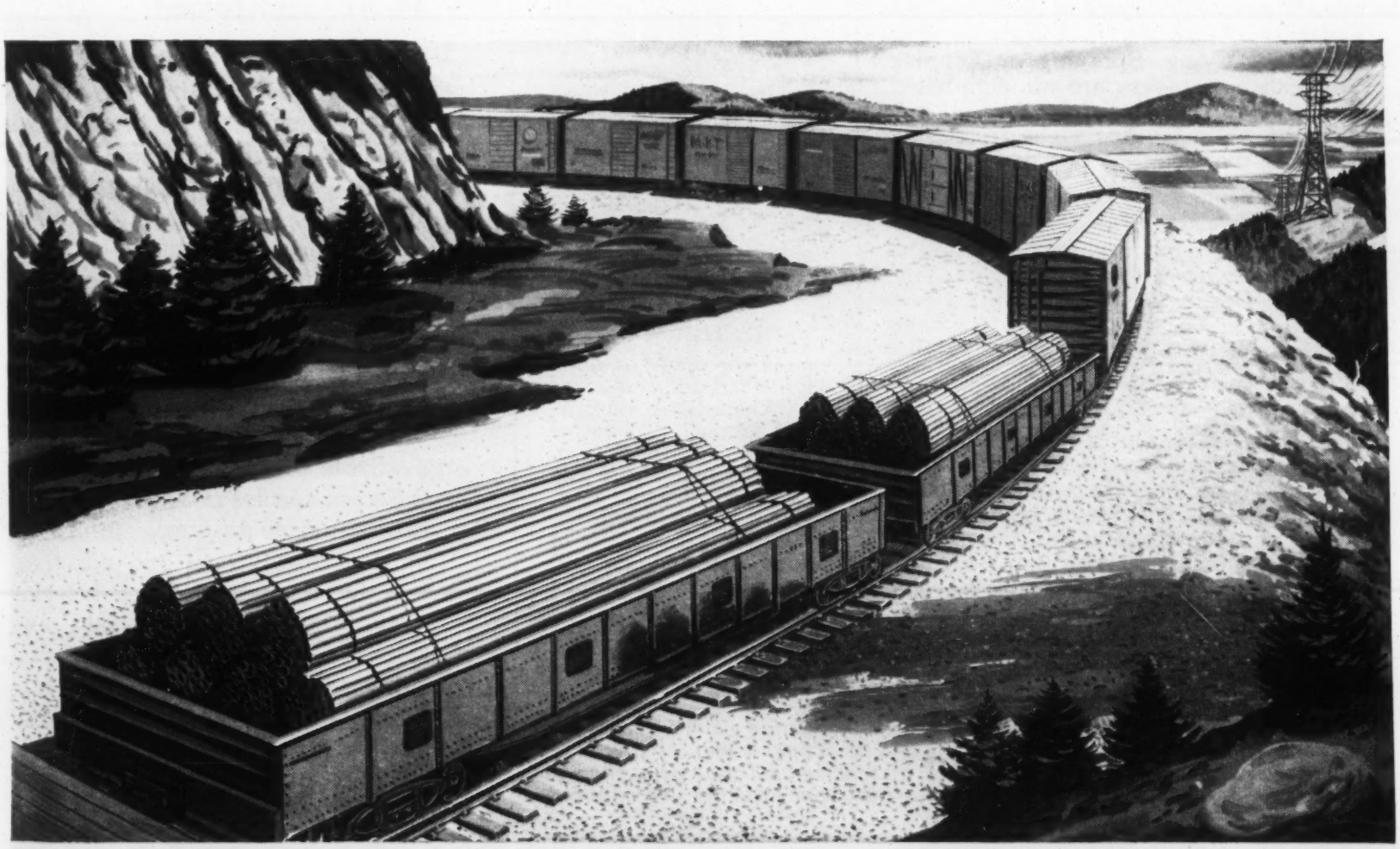
Assured delivery from an integrated mill...

As a buyer of steel tubing, what does the phrase . . . "from an integrated mill" mean to you?

To most of our customers it means just this: no company likes to have its markets jeopardized by production slow downs resulting from material shortages. When the "material" happens to be tubing and the supplier is an integrated mill such as Brainard, such shortages are virtually non-existent.

As an integrated mill, Brainard is not dependent on outside material sources. The corporation of which Brainard is a part controls tubing production from raw material source to finished product: thus customers are assured of an uninterrupted supply.

So, whether you buy tubing in small quantities or carload lots, you can benefit from this year-in-year-out dependability of supply by placing your orders with Brainard.



Brainard Steel Tubing

SHARONSTEEL

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

258

For more information, turn to Reader Service card, circle No. 530

ENAMELSTRIP
PRE-COATED METAL COIL
. . . Ready for Fabrication!

GOES FROM RECEIVING PLATFORM TO ASSEMBLY LINE, SAVING

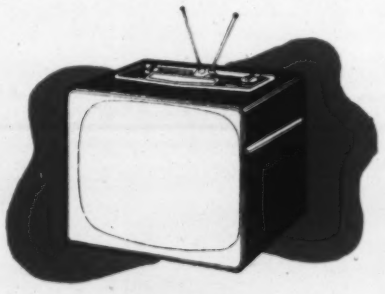
5 OPERATIONS!

Eliminates 5 Operations
Shut down your paint shop when you switch to Enamelstrip. Cleaning, Pretreating, Drying, Spraying or Dipping, and Cutting-to-size are all eliminated. Enamelstrip Pre-Coated Metal Coil goes into the assembly-line right from your receiving platform!

Improves Quality
Enamelstrip's pre-coated finish permits stamping, piercing, forming, and deep and severe drawing without damage to the coating. Enamelstrip is the only pre-coated metal coil certified for quality and performance by the United States Testing Company.

Supplied to Your Specifications
Enamelstrip is available in the following organic coatings, coated one side, both sides, or bi-colored with a different color on each side: alkyds, vinyls, epoxies, phenolics, oleoresinous and other types of enamels and lacquers. Base metals include cold rolled steel, tin mill black plate, electrolytic tin plate, electro galvanized steel, aluminum, brass, copper, and zinc.

Vinyl Laminated to Metal



PORTABLE TELEVISION SET
One of the many products beautified and improved with Enamelstrip vinyl-to-metal laminates. Whether on steel or aluminum, Enamelstrip laminate can be formed, drawn, bent, pierced, and stamped. Offered in a large variety of colors, embossings, and colorprints in numerous color combinations.

Cuts Production Costs
Enamelstrip cuts costs all along the line. It speeds production while reducing labor man-hours. It eliminates waste from cutting and trimming. It reduces your inventory and storage space requirements, and by dispensing with your paint shop and its costly and hazardous operations, cuts your insurance expenses to a minimum.

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Certified for End-Use Performance

ENAMELSTRIP CORP.
Allentown, Pennsylvania
Sales Agents
COATED COIL CORPORATION
505 West 30th Street, New York 1, N. Y.

For more information, turn to Reader Service card, circle No. 539

used phosphor crystals in hardness, machinability, chemical stability and water absorption.

With availability of larger diameter fluors, scintillation counters are expected to find use in such applications as measurement of total energy loss by very energetic particles; cosmic ray measurements; biophysical measurements; weapons tests; and aerial survey mapping of ore deposits.

The plastics fluors are available in rod forms in diameters from 3 to 18 in. and in lenghts up to 36 in. The material may also be ordered cast to predetermined shapes and sizes.

Flexible Wood Veneer Is Scratchproof

A new wood veneer that is said to require no finishing and is completely flexible has been introduced by David Feldman & Associates, Santurce, Puerto Rico. Known as Microveer, it is made of hardwood veneers 0.04 in. thick.

According to the producer, the wood veneer is scratchproof; is unaffected by heat, cold, moisture, sunlight and most chemicals; and cannot be scorched by a cigarette or lighted match. The veneer is available in more than a hundred different species of hardwoods and can be affixed to steel, aluminum, hardboard, plywood and glass.

It is recommended for interior body trim of autos, busses and railway cars; and for aircraft bulkheads, television cabinets, furniture of all types, metal wall partitions, and decorative panels for radios.

Preventing Failure in Plated 4340 Steel

Fracture of cadmium plated high strength steel (AISI 4340) may occur in service after a period of time under an essentially

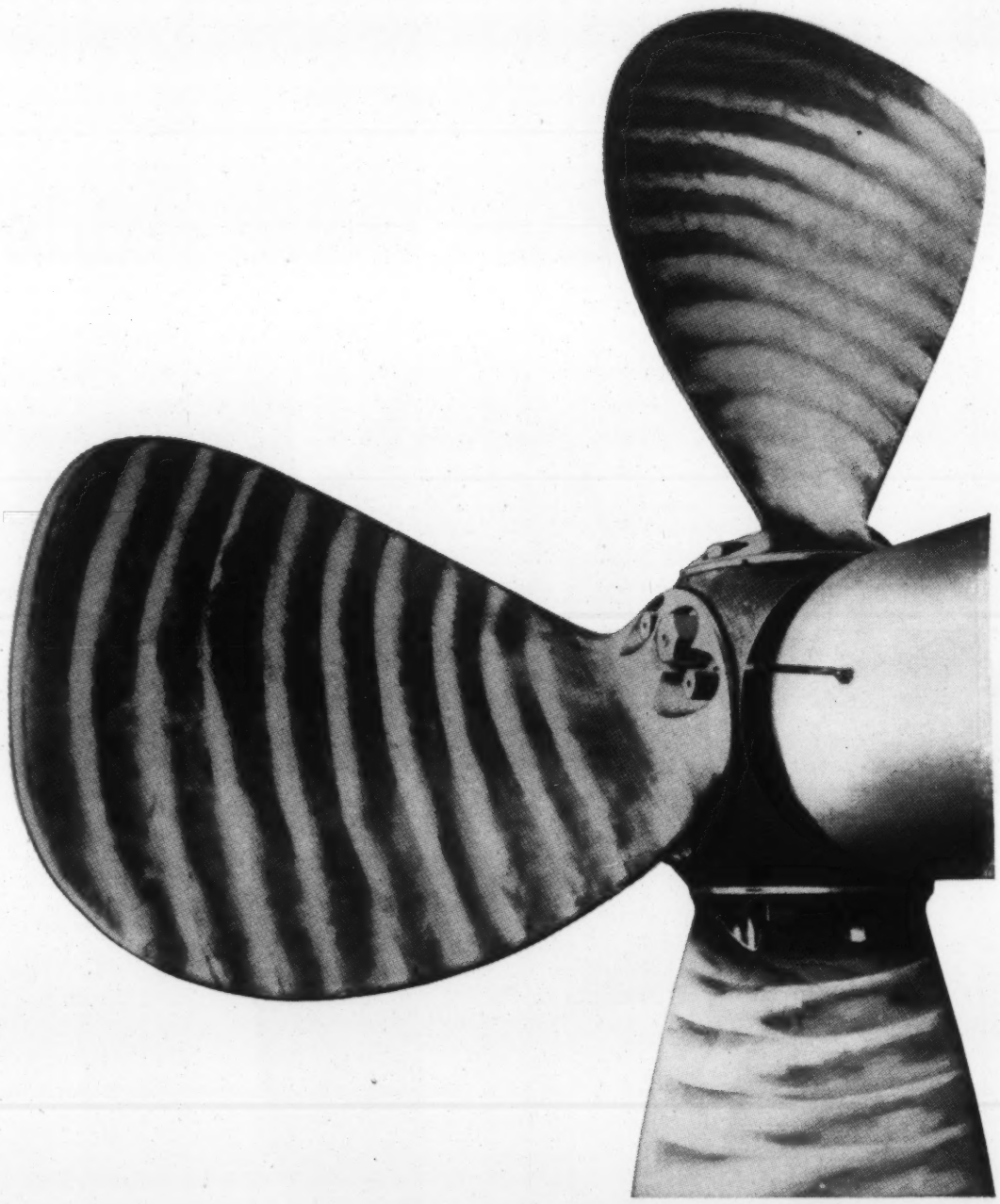
STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern castings

Through modern casting techniques, you can get all the useful qualities of stainless steel in everything from small intricate parts to large precise shapes.

For example, stainless steel is giving giant ship propellers new toughness and resistance to corrosion and erosion. This means that peak speeds and efficiency can be sustained much longer. The "work hardening" property of stainless steel minimizes wear and cuts operating risks, too.

This combination of stainless steel and casting techniques gives design engineers a powerful tool to improve the effectiveness and "sales appeal" of their designs. For more information, write: ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.



Ingeniously constructed of four blades and hub, cast separately and bolted together, this stainless steel propeller defies corrosion and erosion . . . maintains "original design" efficiency.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

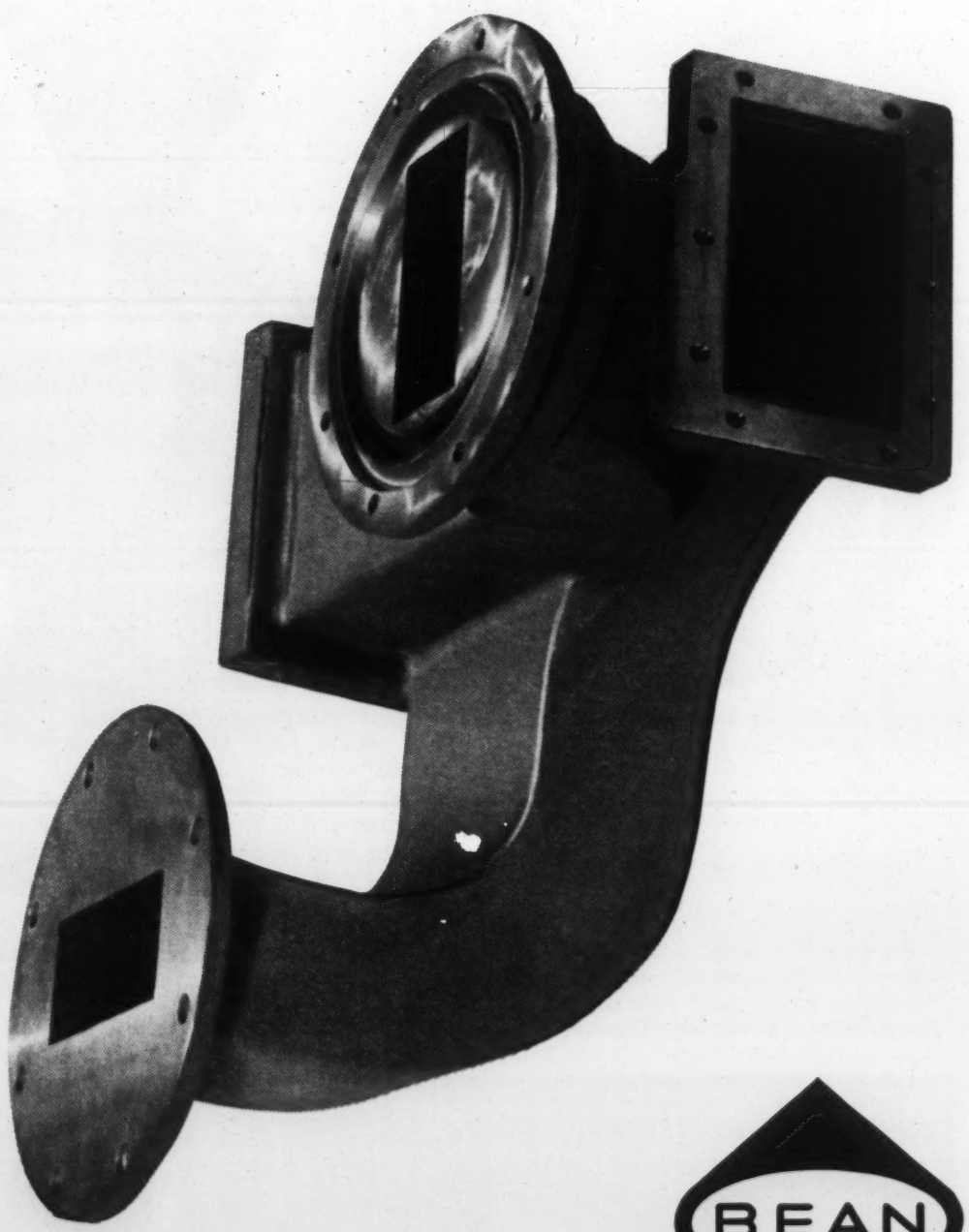
For more information, turn to Reader Service card, circle No. 532

In this S band directional coupler, tolerances on all openings and interior common wall thickness are held within 0.005". The 6 pound pressure-tight casting replaces a difficult fabrication. Our unusual foundry methods are particularly suited to larger aluminum castings in which intricacy, density, accuracy and surface finish must be of a high order.

Electronics parts too large or too complex for conventional fabrication and casting methods may often be just the thing for Morris Bean & Company. Write for our illustrated wave guide literature.

Morris Bean & Company
Yellow Springs 1, Ohio

complex cast wave guide



BEAN

For more information, turn to Reader Service card, circle No. 556

constant stress much lower than the yield strength of the steel. This phenomenon, described as "delayed fracture," is associated with the presence of hydrogen in the steel. The hydrogen may be introduced in the steel by reaction with water vapor or other hydrogen-bearing gases while it is in the molten state, but it is also introduced by reaction with water and acid in zinc, cadmium and chromium plating operations.

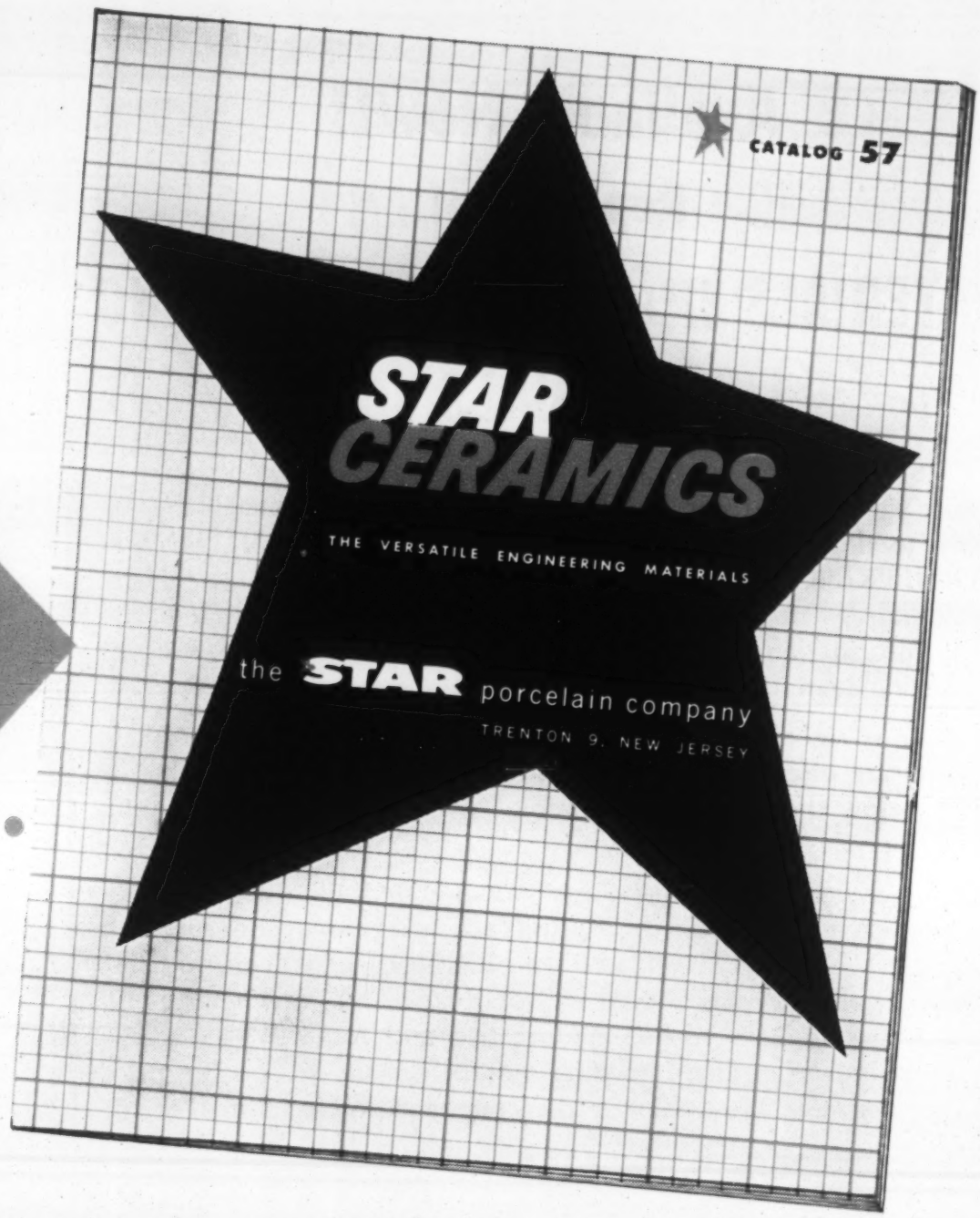
Vacuum and air melted 4340 steels, low in initial hydrogen, are highly susceptible to failure by delayed fracture after plating. Studies of delayed fracture in unalloyed high carbon steel under stress loading indicate that baking cadmium plated steel at 400 F eliminates delayed fracture. Constant rate bend tests on chromium and cadmium plated stainless steel (type 440C) show that hydrogen is removed by baking the metal at temperatures as low as 212 F.

Baking tests

Recently, B. F. Brown, of the Physical Metallurgy Branch, Naval Research Laboratory, conducted a series of tests to evaluate the effectiveness of baking treatments in lowering the hydrogen content of zinc, cadmium and chromium plated high strength steel. The object of Mr. Brown's investigation was to study possible ways of lowering or eliminating embrittlement of plated steels, rather than to devise means to prevent embrittlement. AISI 4340 steel was tested since it is used extensively in the aircraft industry for such critical parts as bolts, tubing and heavy forgings. All these parts may be plated with cadmium for corrosion resistance, and some may be plated with chromium for wear resistance.

There is no sharply defined strength level above which cadmium plating causes delayed fracture and below which it does not, but rather experience shows that there is a continuously rising sus-

YOU'LL FIND IT ALL HERE



If you are looking for new ways and means to improve your product, *and save money too,* here's an idea source guaranteed to spark your imagination and give you a wealth of hints, tips, and suggestions.

This 20-page fact-filled STAR catalog contains complete descriptive and engineering data on the full line of STAR Ceramics . . . COMMERCIAL WHITE PORCELAIN, NU-BLAC®, THERMOLAIN®, STEATITE, VITROLAIN®, HUMIDOLAIN®, LAVOLAIN®, and 5606 REFRACTORY. A big selection chart, complete with mechanical and electrical properties, makes the job of selecting the right STAR material for your product a cinch.

And, that's not all! There's a lot more information as well . . . data that you'll find of constant value. Like a free copy? Send for one *today* . . . we'll do the rest. Ask for Catalog 57.

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What's new IN MATERIALS

ceptibility to delayed fracture with rising strength levels. In the series of tests, Mr. Brown investigated cadmium, zinc and chromium plated AISI 4340 steel heat treated to strength levels of 180,000, 225,000 and 285,000 psi. He found:

How treatment worked

1. Baking at 350 F for 24 hr completely removes the susceptibility to delayed fracture of chromium plated steel, but is only partially effective in cadmium plated steel and is completely ineffective in zinc plated steel. Increasing the baking temperature (within limits imposed either by tempering temperature of the steel or by volatility of the plating) may or may not be effective above 350 F.

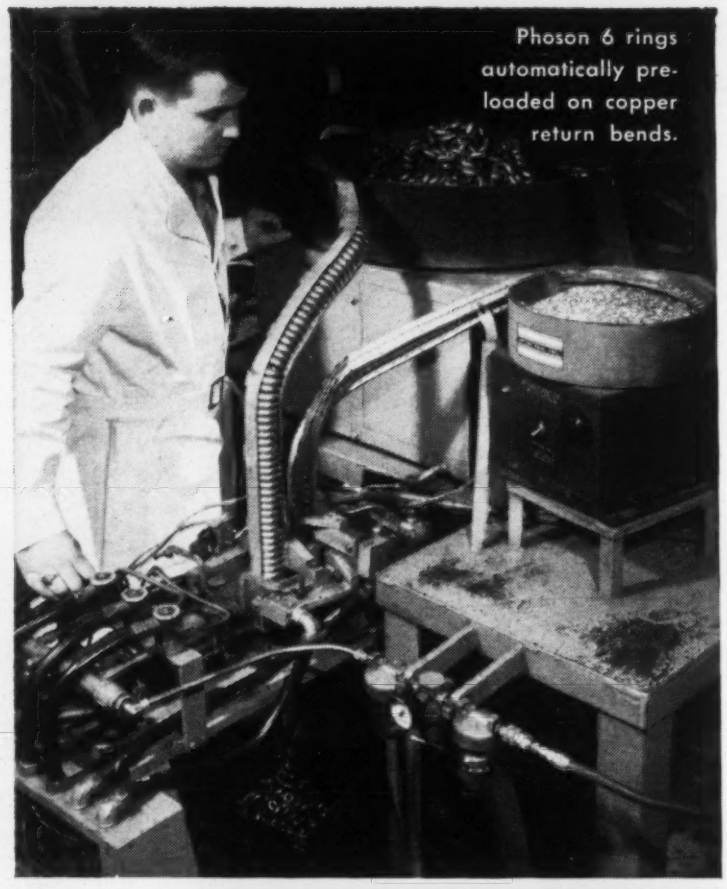
2. The higher the strength level of the plated steel the less effective is the baking treatment.

3. Since zinc, chromium and cadmium plated specimens behave differently in baking, any improvement from baking represents a loss of hydrogen through the plate rather than redistribution of hydrogen within the body of the steel.

4. Regardless of baking treatment, susceptibility to delayed fracture remains in 4340 steel cadmium plated from a cyanide bath. A possible solution to this problem is the use of an electroplating bath that either does not discharge much hydrogen or, alternatively, gives a plate with sufficient porosity to permit exit of hydrogen.

Fluorocarbon Aerosol for Coating Small Parts

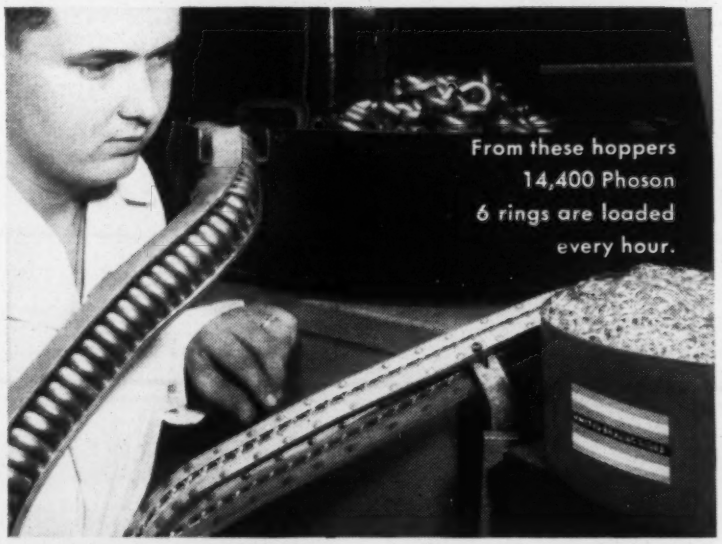
A fluorocarbon resin (trifluorochloroethylene) is now available in pushbutton aerosol containers for spray coating of small metal and ceramic parts. Available from Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill., and called Polyfluoron, the aerosol product



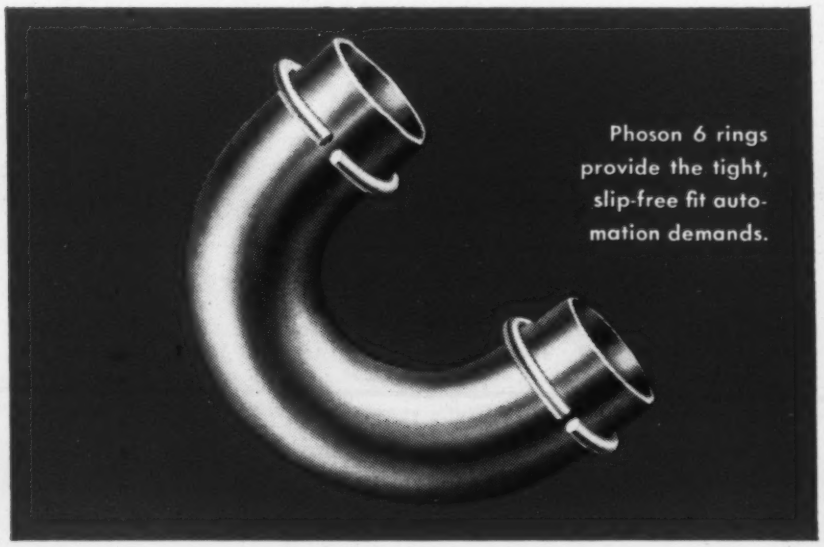
Phoson 6 rings automatically pre-loaded on copper return bends.

UNITED PHOSON 6 MAKES AUTOMATION IN BRAZING PRACTICAL... HIGHLY PROFITABLE

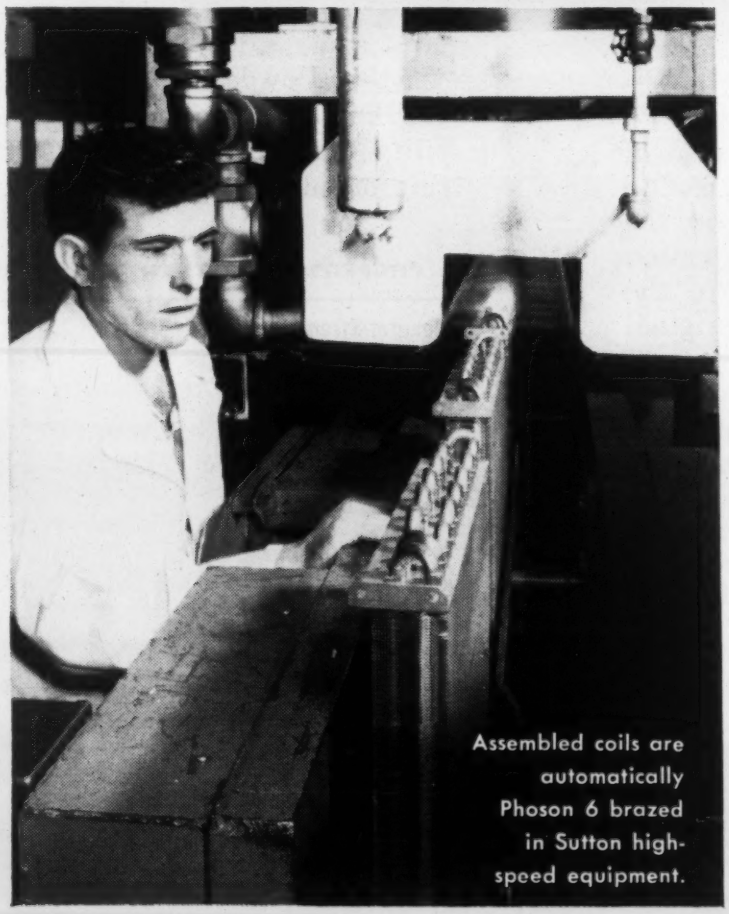
Brazing, too, can be fully automated. With the equipment shown, brilliantly engineered by The O. A. Sutton Corporation, up to 14,400 brazing rings are loaded every hour. Thanks to the high quality and precision tolerances of Phoson 6 rings, this company, one of the world's leading manufacturers of comfort cooling appliances, has increased assembly speed of copper return bends by 12 times!



From these hoppers 14,400 Phoson 6 rings are loaded every hour.



Phoson 6 rings provide the tight, slip-free fit automation demands.



Assembled coils are automatically Phoson 6 brazed in Sutton high-speed equipment.

To permit this amazing speed, brazing rings must fit tightly — perfectly — completely eliminating slippage prior to brazing. Here's how United Phoson 6 rings meet all the strict precision requirements of automation:

FIRST . . . Rings of Phoson 6 are preformed to exacting and uniform tolerance of +.000″ to −.005″ ID with a maximum helix of .015″.

SECOND . . . at the lowest practical temperature, Phoson 6 brazes leakproof joints of highest strength, ductility, corrosion resistance and thermal conductivity.

These two points add up to one fact. You can profit now from automated brazing! Without delay, get the whole story. Write direct to United or see your nearby United Welding Supply Distributor.

Permanently United

UNITED WIRE
AND SUPPLY CORPORATION

PROVIDENCE 7, RHODE ISLAND

COPPER, BRASS AND ALUMINUM WIRE AND TUBE . . . BRAZING ALLOYS, PHOSON, SIL-BOND

For more information, turn to Reader Service card, circle No. 493

HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE

The Therm-O-Disc Type E Series Thermostat is designed for compact installations in clothes dryers, room and unit heaters, central heating furnaces, air conditioning and ventilating equipment, aircraft and miscellaneous devices, for controlling temperatures up to 350°. Both the EA and EC Series are for single pole, single throw operations and can be supplied with normally closed or normally open contacts. The EA (shown) is best suited for controlling temperatures in air streams; the EC is intended for surface mounting. Both types are actuated by an exposed disc of Chace Thermostatic Bimetal, altho EA is also available with enclosed disc for protection against dust, lint, moisture, etc.

Here's how Therm-O-Disc works; The pre-calibrated disc of Chace Thermostatic Bimetal snaps from a normally concave to convex form at the pre-set point of temperature rise, in the manner of an "oil can". The impact of this positive snap action against a bumper causes instantaneous make or break of the contacts or circuit. Upon cooling, the disc snaps into the original concave form, resetting the contacts.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal", containing interesting uses of bimetal and many pages of engineering data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service card, circle No. 536

What's new IN MATERIALS

is said to offer the same application advantages, in small scale operations, that are attained with power spraying equipment in large commercial coating jobs.

According to the producer, the resin can be applied in heavy film thicknesses without surface cracking. Film thickness can be varied by building up light spray coatings and allowing 1 to 5 min between coatings for evaporation of the solvents in the aerosol dispersion. After the coating is applied it is fused in a vented oven at 480 F, then quenched in cold water. Coatings of 3 to 5-mil thickness are recommended for moisture resistant coatings, and coatings of 3 mils for antitack or antistick applications.

Typical applications include corrosion resistant linings for tanks and pipes, moisture seals, magnet wire insulation, and chemical valve linings.

Reinforced Polyester Is Easy to Mold

Atlas Powder Co., Wilmington 99, Del., has announced the availability of a new glass fiber-reinforced polyester molding com-

PROPERTIES OF THERMAFLOW 800

Flexural Strength, psi	23,000
Compressive Strength, psi	22,000
Tensile Strength, psi	8000
Modulus of Elasticity, psi	2×10^6
Heat Distortion (264 psi), F	>450
Arc Resistance	150
Dielectric Constant	
1 kc	5.27
1 mc	4.72
Dissipation Factor	
1 kc	0.03
1 mc	0.015
Insulation Resistance, megohms	$>1 \times 10^7$
Dielectric Strength, v/mil	
Short-Time	300
Step-by-Step	245
Dielectric Breakdown, kv	
Short-Time	53+
Step-by-Step	47+
Volume Resistivity, ohm-cm	15×10^{14}

A Man Nobody Wants

This man's motto is "Don't rock the boat!" Now that he has reached his present high post in the Company, his life is dedicated to proving that once you get a good thing, you don't have to change. In fact, if things get too new, you can always search the past for something really safe to use.

He, naturally, has no interest in the new things coming out of Rogers.

Rogers is not looking for him, either. Rogers serves engineers – those men who sail the seven seas in search of an eighth. And they, in turn, find Rogers an interesting port of call – a cove of research and development brains eager to meet the challenge of their ideas with new materials.

Our business is to create – if we don't already have them – the materials that engineers are seeking to convert today's dreams into actual products. Please write for samples of recent developments.

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DUROIDS—for Gaskets, Filters, Electronic Devices, Thermal Insulation, etc. ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc. PLASTICS—Special Purpose Molding Compounds and Laminates RUBBER—for Floats, Grommets, Gaskets, Bearing Seals, etc.
FABRICATING—Including Converting, Combining, Coating, Embossing, and Molding DEVELOPMENT—Research and Engineering of Unique Materials, Parts and Products

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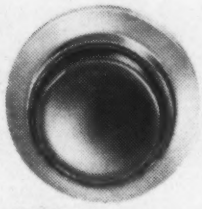
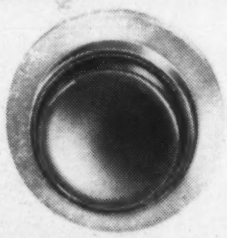
In this Pushbutton World

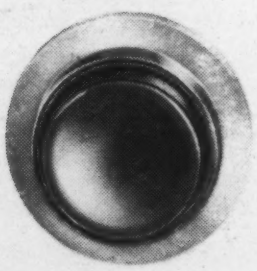
it's important for manufacturers



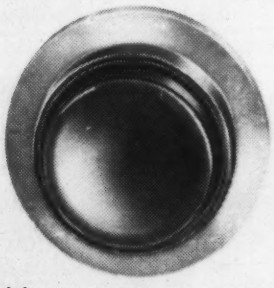
and designers who would fully



benefit from the application



of quality phenolics—



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SHEBOYGAN, WISCONSIN

PLENCO PHENOLICS

FOR BETTER PLASTIC PRODUCTS

Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

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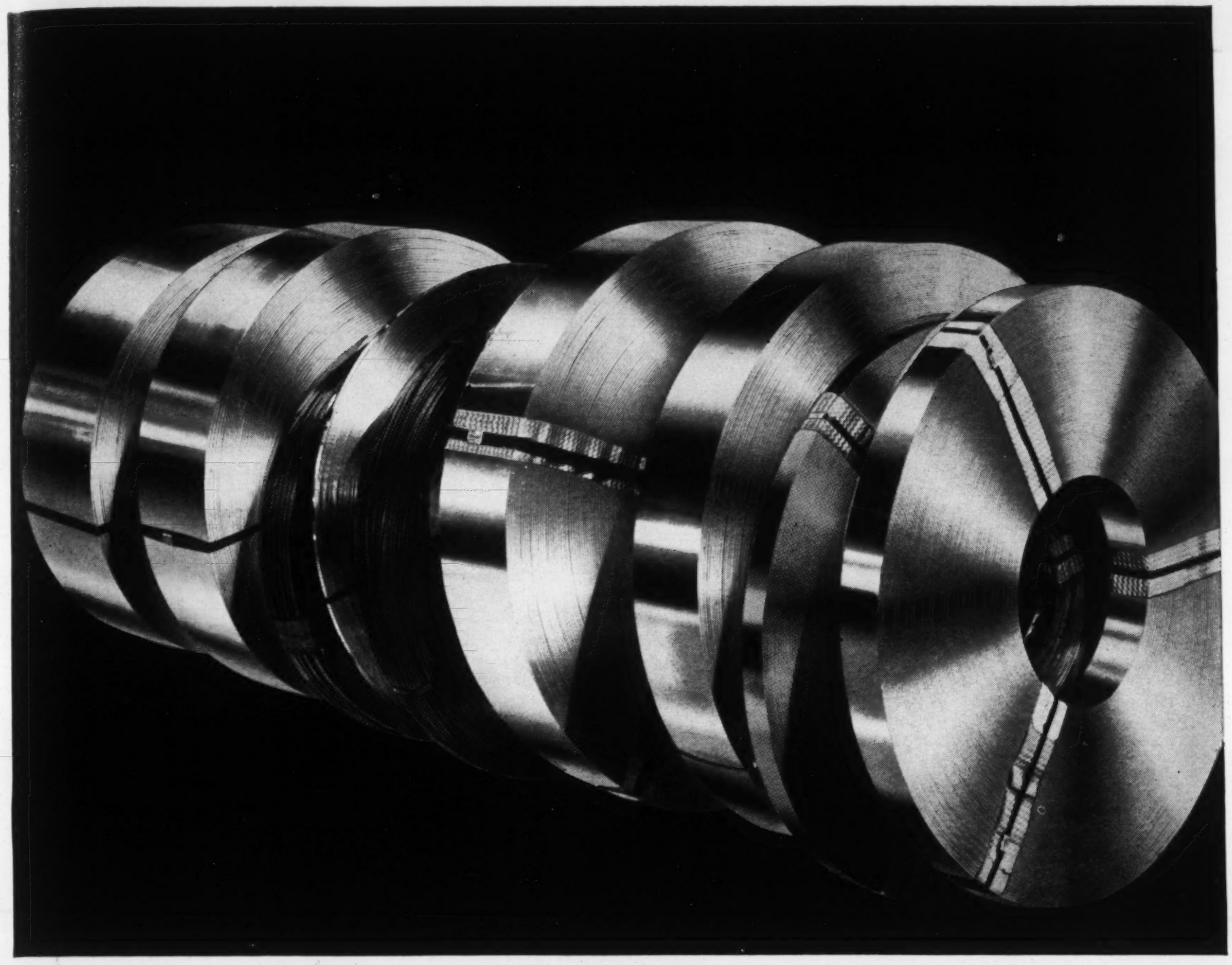
pound to meet military specification MIL-M-14E for alkyd high impact compounds. Called Atlac Thermaflow 800, the compound has good heat, flame and electrical resistance, and is said to have better moldability than other materials meeting this specification. According to the producer, large and intricate parts, formerly made of several pieces of metal, can now be made from this reinforced plastics material in one piece.

Principal uses for molding compounds meeting this military specification are electronic computer parts, electrical fuses for projectiles, and electrical housings for aircraft, tanks and ships.

Plastics Vanes Used in Air Compressor

Laminated plastics vanes, made of a specially processed fine weave cotton fabric impregnated with thermosetting phenolic resin binders, are being used in a new type of air and gas compressor called the rotary sliding vane compressor. The new type compressor is said to provide many of the advantages of both reciprocating piston and turbo type compressors with few of their drawbacks. The rotary compressor provides the same positive displacement of air as the reciprocating piston type and has the turbo type's advantage of not starting under load.

In a typical rotary vane compressor, plastics sliding vanes are thrust against the pump housing by a centrifugal force forming a sealed-off compartment that provides a positive-displacement type of air pumping action (see sketch). Plastics vanes are used because they are softer than the metal housing and wear is confined mainly to the vane rather than to the metal housing. Wear on the vanes is greatly reduced because the laminated plastic is much lighter than metal, and vane



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Crucible has the largest assortment of cold rolled specialty steels you'll find anywhere. And delivery is dependable—in the size, grade, gauge, or analysis you want.

What's more, Crucible's steelmaking experience—its improved mill facilities—combine to bring you cold rolled steels of optimum uniformity . . . finer finish . . . better edges . . . flatter strip.

No need to shop around—call Crucible for carbon spring steel, alloy strip steel, or *any* ferrous analysis that can be cold rolled. For more information, write now for your copy of the 32-page booklet, "Cold Rolled Specialty Steels". *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

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Centralab High Alumina Ceramic

Centralab High Alumina ceramic can be fabricated in any shape, form, or size — to exacting tolerances — for applications requiring exceptional strength, greater shock- and heat-resistance.

In addition to its superior electrical characteristics, Centralab High Alumina ceramic is chemically inert and remains stable under radiation bombardments, elevated temperatures, and controlled atmospheres.

Centralab High Alumina ceramic is available in production quantities — in 85% and 95% unmetallized or metallized bodies.

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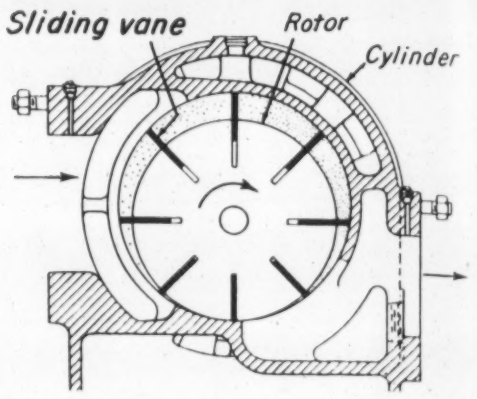
One of America's largest manufacturers of engineered ceramics. Regardless of requirement, Centralab specialists and facilities can produce the High Alumina ceramic-component design you want.

X-2358



Air compressor *uses laminated plastics sliding vanes.*

replacement is seldom required during the life of the compressor.

The laminated plastics vanes, produced by Synthane Corp., Oaks, Pa., do not swell or warp when exposed to lubricating oils, high temperatures, gases or moisture-laden air that are often present in compressors.

The rotary pumps with plastics vanes are being successfully applied to air motors and superchargers for internal combustion engines.

Vinyl Plastisol Finishes Cover Pitted Castings

A series of sprayable vinyl plastisol finishes called Flintlok and Tufkote has been developed for use on all types of manufactured metal goods by Auburn Button Works, Chemical Div., 1930 Canoga Ave., Auburn, N. Y. The finishes are said to be unaffected by cold, heat, salt air and water, and are moisture, mildew, fungus, acid and alkali resistant.

The Flintlok series requires no primer and produces upon curing a hard, flinty surface of 95 Durometer C hardness. The finishes, available in a variety of colors, are recommended for use on appliances and office machines.

The Tufkote series of finishes is said to provide a thick coating in a variety of textures ranging from shiny surfaces to pebble,

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Standing ready to serve you!

Your local steel distributor plays a vital role in your production picture. He supplies that all-important material—steel—in any amount, size, or shape, from his well-stocked warehouse. And he delivers immediately upon demand!

Whether you need a small quantity of steel to wind up a job without going back to the mill—or a medium-size quantity to supplement your present supply—your distributor is capable and instantly ready to fill any need. He's truly "at home" with your problem, regardless of its size.

Your local warehouse distributor is indeed the strongest link between the mill and you—an indispensable supply source. And he's never any farther away than your telephone.

Call him for any quantity of Weirkote zinc-coated sheets—Weirzin electrolytic zinc-coated sheets—or hot or cold rolled sheets. You'll be surprised at the scope of the services he offers you . . . courteously and punctually.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

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Fansteel 77 Metal

"steadies" this B-52 fueling boom...

One of the Fansteel 77 Metal weights used to dampen vibration in jet tanker boom.

Air turbulence can make this hook-up about as easy as threading a needle in a windstorm. Boeing design engineers created an unseen "steadying hand" by installing Fansteel 77 Metal damping weights in the boom end of this "filling station in the sky"—packing a lot of weight into a small space. For 77 Metal is *twice* as heavy as steel.

Fansteel 77 has a lot of down-to-earth uses too, such as shields for radioactivity, as rotors, governors and balancers. Fansteel 77 is pressed into shape from powder so there is negligible scrap loss. It has high tensile strength (105,000 psi) as well as high yield (85,000 psi). It machines as easily as cast iron.

If you are trying to conquer anything from wild vibration to annoying chatter, a letter to Fansteel will probably save you a lot of time and trouble.

Write for this FREE BOOKLET

K574A

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U. S. A.

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wrinkle and leather grain. These finishes are designed to fill and cover rough, pitted and porous metal surfaces; grinding and finishing operations on castings and forgings can be eliminated or reduced to rough clean-up, it is claimed. According to the producer, thicker coats can be obtained by multiple applications with abbreviated cure cycles between each coat.

3-D Aluminum Sign

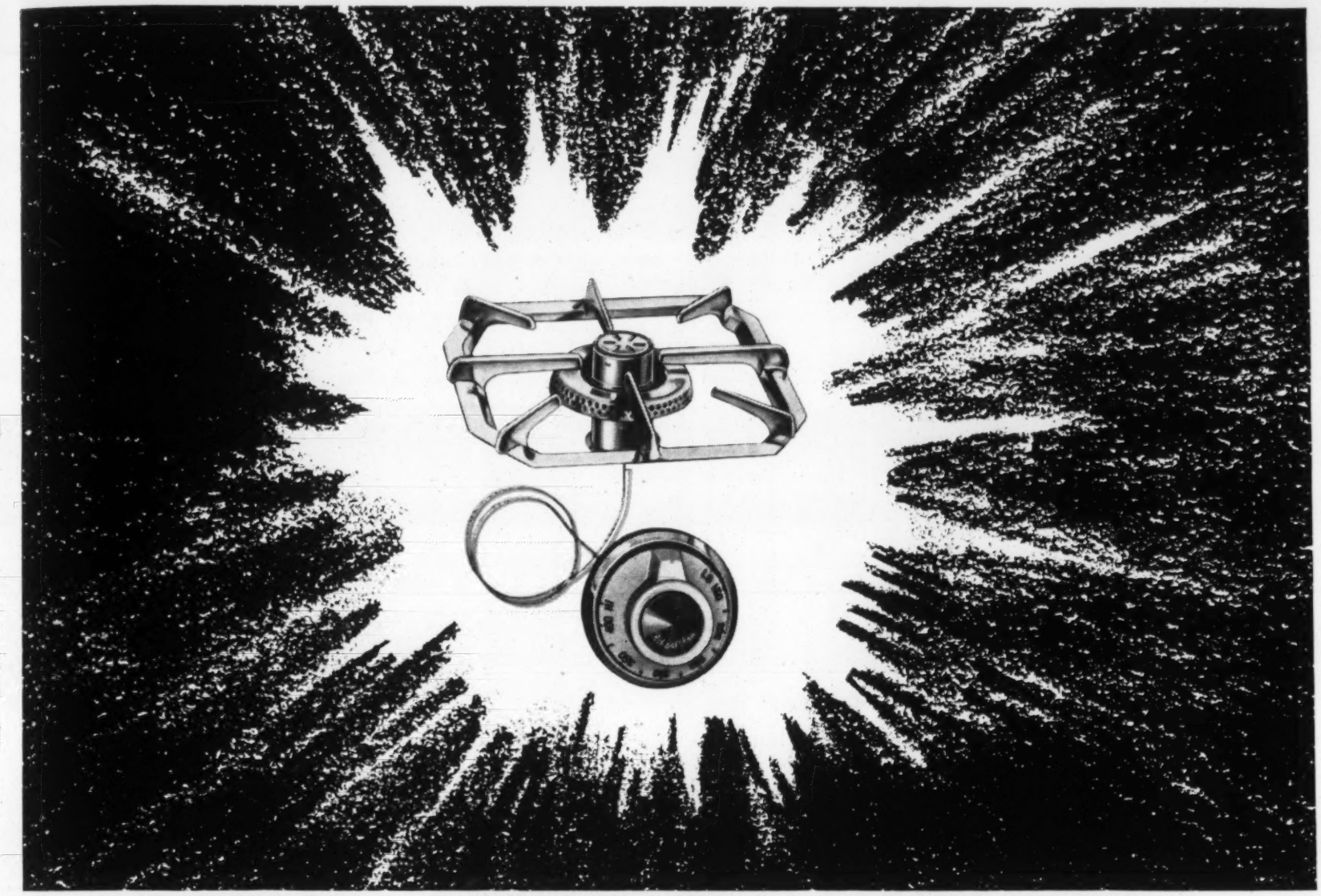
What is claimed to be the first all-aluminum, three-dimensional outdoor sign has been erected for Reynolds Metals Co. on a highway in Louisville, Ky. The sign, composed of an all-aluminum frame, back panel, facing and three-dimensional projections, was fabricated and erected by General Outdoor Advertising Co.

Aluminum, according to Reynolds, has a number of advantages as a sign material. In addition to ease of fabrication, resistance to rust and corrosion, and high reflectivity, its light weight makes for easier and less costly handling.

Polystyrene Shields Absorb Stray Light

A polystyrene shield for fluorescent light fixtures has a velvety, flat surface finish that absorbs stray light and prevents distracting reflections. Called Frost-White, the shields are made of a modified polystyrene resin developed by Sheffield Plastics, Inc., Sheffield, Mass.

According to the producer, the shields combine a reflection-free surface finish with extreme flexibility and impact strength. The shields are said to retain their initial color for over 20,000 hr of actual lighting use, whereas regular polystyrene shields discolor after 15,000 hr of lighting.



THE MAGIC THERMAL EYE CONTROL MANUFACTURED BY ROBERTSHAW THERMOSTAT DIVISION OF ROBERTSHAW-FULTON CONTROLS COMPANY.
IT IS USED ON MORE THAN 40 DIFFERENT HOUSEHOLD RANGES.

Robertshaw Controls "Help The Cook Get off the Hook!"

—With Precision-Controlled Tube by WOLVERINE

Nowadays—thanks to gas and electric thermostatic controls by Robertshaw®—it's difficult for a cook to spoil the broth or ruin the bacon because of overcooking.

Taking the guesswork out of cooking isn't easy—requires, in fact, exceptional precision in the manufacturing of the thermostatic controls. That's why, for example, Robertshaw uses small diameter Wolverine copper tube of rigidly controlled quality for the capillary of its new Thermal Eye® gas control. This highly responsive unit senses the temperature of cooking food and keeps it at a predetermined level—for many hours if necessary.

Precision control in all such instruments, say Robertshaw engineers, depends to a large extent on the built-in precision of the copper tube. This tube contains a temperature sensitive fluid, which by expansion and contraction, regulates the flow of fuel to the burner.

Proof that Wolverine copper tube meets these exacting demands is found in Robertshaw's use of "Miles of Wolverine copper tube each month".

Meeting the specialized demands of individual manufacturers such as Robertshaw is but another facet of Wolverine's continuous Tubemanship program.

When specifying tubing or tubular-shaped parts always remember that, at Wolverine, Tubemanship stands for the perfect blending of experience, research and sound engineering. Make it your "buy" word. Write for Wolverine's General Products Catalog.

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EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK 5791

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Great advances in design . . .

NEED THE ADVANCEMENT IN WEAR RESISTANCE PROVIDED BY FLAME-PLATING BY LINDE

Lockheed's F-104A Starfighter, newest weapon of the Air Force, is the most advanced airplane of its type. To give them the greatest possible resistance to extreme conditions, bearing surfaces *(arrows)* of hot air valves used in the F-104A are Flame-Plated with tungsten carbide. Flame-Plating provides the wear-resistant coating needed to withstand the high unit loading and temperature extremes jet plane parts undergo.

Stratospheric altitudes . . . supersonic speeds . . . extreme temperatures subject jet plane parts to almost incredible conditions of heat and abrasion. To assure perfect operation in all circumstances, bearings of hot air valves in the Starfighter are Flame-Plated. A tungsten carbide coating, applied by LINDE's unique method, is the only material tried that successfully eliminated galling and provided a low coefficient of friction over the required service life of the part. With the part Flame-Plated, practically no wear occurred. This LINDE process is now a regular production procedure.

Flame-Plating is LINDE's special process for protecting metal parts from wear, abrasion, and fretting corrosion. Tiny particles of tungsten carbide or aluminum oxide are literally *blasted* onto the metal surface. Since the temperature of the part being coated seldom exceeds 400 degrees F., there is little or no risk of changes in its shape or metallurgical properties. Flame-Plated coatings can be applied from .002 to .010 inches thick, and used as coated or finished to 0.5 microinches rms. Practically all metals can be Flame-Plated—aluminum, magnesium, molybdenum, titanium as well as copper and steel.

Your own design may be improved by Flame-Plating. Find out how, by writing for a copy of the booklet "Flame-Plating," F8065. Address Flame-Plating, Dept. N-8. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.
In Canada: Linde Company, Division of Union Carbide Canada Limited.

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TRADE-MARK
UNION CARBIDE

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If you require a material with properties such as these:

LOW DIELECTRIC LOSS FACTOR • HIGH TEMPERATURE STABILITY

EXTREME HARDNESS • EXCELLENT CORROSION RESISTANCE

— it would be well to investigate the possibilities of Alite.

The Alites are a series of sintered metallic oxides developed by The U. S. Stoneware Co. Because Alite possesses the unique combination of electrical and physical properties above, it is finding increasing use in critical applications involving stringent electronic and/or mechanical requirements.

Alite retains its mechanical characteristics at working temperatures well above 2000° F. It maintains low loss characteristics throughout the entire spectrum, into the microwave range. In addition to giving durable service as high-strength insulating components, Alite is used for rotating seals, pump plungers, slide valves, crucibles, sleeve bearings, bushings, extrusion dies, etc.

We can form Alite to practically any shape by extruding, pressing, molding or casting. It can be finished to precision tolerances by diamond wheel grinding and lapping. Alite is abrasion-resistant, vacuum-tight, can be metalized and brazed to metal components.

If "heat-barrier" problems or mechanical limitations forestall improved performance of your product or application, *consider designing for Alite*. We'll furnish complete data promptly. Write today for Bulletin A-7.

382-E

ALITE DIVISION **U. S. STONEWARE**
AKRON 9, OHIO

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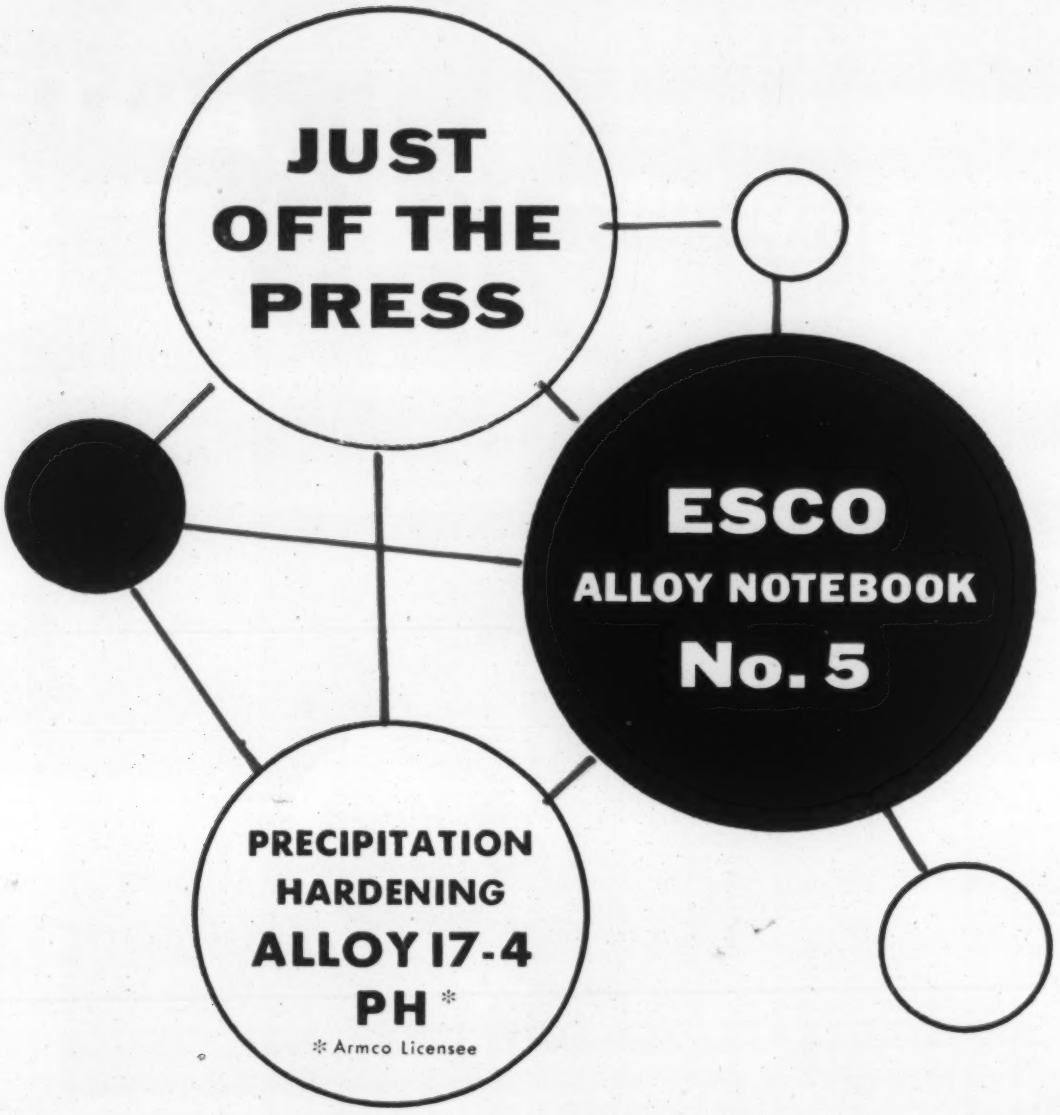

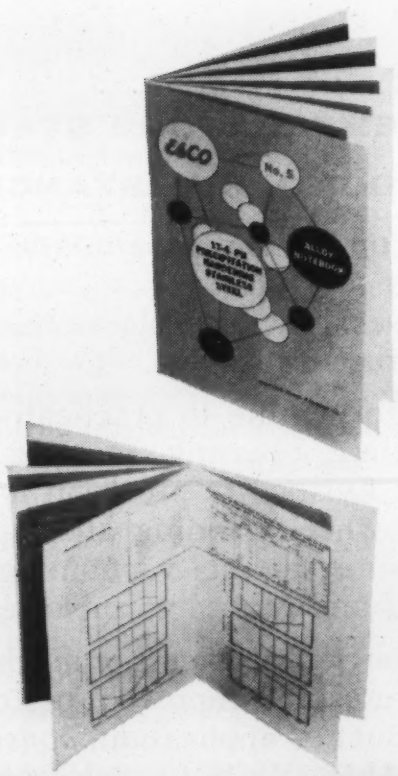

Here is the first information published on the mechanical properties after various heat treatments, of cast alloy 17-4 PH. This true heat and corrosion resistant stainless steel can be machined, in its relatively soft as-cast condition, and hardened to 400 BHN at low temperatures. 17-4 PH also has the ability, through heat treating, of being adaptable to a wide range of applications requiring high strength, ductility and impact resistance.

This report of a continuing study contains pictures, tables and graphs, showing such things as the microstructure before and after annealing and the comparative mechanical properties of 17-4 PH.

Industry as diversified as aircraft parts, food processing equipment and chemical pump manufacturers are among the enthusiastic users of Alloy 17-4 PH.

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PRICES AND SUPPLY

The Outlook

by Herman B. Director, Consultant, Washington, D.C.

Steel production continues high

In spite of decreased consumption of steel in both the automotive and appliance industries, production of finished steel will probably approach record levels this year.

Plentiful supply of rare earths

Elements in the rare earth group are now more abundant than lead, tin or molybdenum. New deposits are already known to be sufficient to meet all foreseeable needs, and prospects for additional discovery are good.

Rare earth applications are expanding in metal alloys and in nuclear fields. An important first step to speed the expansion of markets would be to rename this group of elements with a more optimistic supply connotation.

'Supplemental' stockpile knot

As a result of the barter program, the Government has been pumping materials into its "Supplemental" stockpile for years. Unfortunately, the agricultural Trade Adjustments Act of 1954, which set up the barter program and provided for an unlimited supplemental stockpile of materials, neglected to provide authority for withdrawal of the materials even under wartime conditions. Not even the President can order materials taken out, and presumably an act of Congress is necessary. Other Government stockpiles, including the "Strategic" and Defense Production Act inventories, incorporate detailed withdrawal procedures that are applicable under certain conditions. Sponsors of a bill setting up a procedure for emergency withdrawal of manganese, diamonds, chrome, fluorspar, lead, zinc, cobalt, etc., are having a hard time getting their point across to the Congress.

Lead and zinc producers press support

The further drop in lead and zinc prices, which we had forecast (MATERIALS & METHODS, June '57) has stimulated the formation of an Emergency Committee on Lead and Zinc in Washington. The objective is to assure passage of some kind of support program for these two materials. However, little hope has been expressed for passage of a broader "long range minerals program."

The program submitted to the Congress by the Administration was not well received by either Congress or mining advocates. It incorporated an excise tax provision which has raised a controversy within the government as to whether this tax would violate our commitments under the General Agreement on Tariff and Trade (GATT). The Chief of the Tariff Commission has publicly raised this issue.

The Administration's program centers on lead and zinc and is designed to assure a 17¢ per lb price for lead and a 14½¢ per lb price for zinc. The current prices are 14¢ for lead and 10½¢ for zinc.

Foreign suppliers, especially Canada, Mexico, Australia and Peru, are successfully exerting pressures in opposition to the proposed excise tax. Chances of Congressional action this year are not good. Continued Government purchases plus renewal of barter on a limited scale are about all the U.S. producers can expect.

A constructive step taken by the lead producers is the establishment of a new six months' research program at Battelle Memorial Institute aimed at developing new uses of lead and zinc. One example of the loss of a market for lead is noted by Western Electric Co. which reports that of the more than 100 billion feet of cable produced in 1956, only 20% was lead covered. The balance was covered with polyethylene.

Nickel supplies continue to increase

The last obstacle to complete diversion of nickel from delivery to the Government in favor of delivery to industry has been overcome. Sherritt-Gordon Mines Ltd. has agreed to divert an additional 2.5 million pounds per quarter to industry. Total availability

PRICES AND SUPPLY

The Outlook—continued

for industry for all uses, both defense and nondefense, is now over 25 million pounds per month, as compared with about 21 million pounds per month this time last year—an increase of about 20%. As a result, production of stainless steels and other nickel-bearing materials should increase accordingly.

Users' bite on tree includes bark

Forest products manufacturers claim that they now use 70% of the tree, including the bark, and they are pushing on. They make wood pulp, kraft pulp, plywood, glue and plastic extenders from bark. Particle board and fire logs are made from shavings.

Production of synthetic rubber increasing

A combination of circumstances favors expansion of synthetic rubber as compared with natural rubber. For one thing, synthetic rubber is more easily adapted to specific applications. For another, natural rubber production is subject to natural growth limitations and violent price fluctuations.

Consumption of rubber in the automotive industry continues to increase. However, since natural rubber production is fairly stable, the synthetic product soaks up the annual growth in rubber requirements.

Use of aluminum pushed by producers

The aluminum industry is well along in its multi-million dollar promotional campaign to spur aluminum uses. The industry is happily not content with the prospects of selling its excess supplies to the Government stockpile. The promotional campaign is emphasizing major consuming areas such as automotive and building products and, with Kaiser in the lead, is pressing forward into the rigid container market. Nobody expects the aluminum industry, which now produces slightly less than 2 million tons per year, to overtake the 4 million ton annual tinplate market. Serious entry into the container market by the aluminum people, however, will result in better competitive container products for the benefit of consumers.

Copper price politics

Foreign copper producers, notably Rhodesian, are considering the possibility of revising their methods of marketing copper. The ultimate purpose would be to introduce on the London Metal Exchange a single price system to give "greater stability" to world quotations. It is significant that little was heard about stabilizing the price when it was increasing. Now that the price is continuing to decrease, the question of stability comes under serious discussion. The Union Miniere sells Congo copper at a fixed price, as does the Selection Trust. Other producers do not sell at a fixed price. A decision to sell all copper at a fixed price would in effect make the London Metal Exchange copper price a controlled price. Disparity between U. S. and London prices would be much less likely to occur in the event that an agreement is reached by the foreign producers.

Although consumer demand for copper appears to have picked up somewhat in recent months, supplies are more than adequate and the predominant trend on the part of the producers is still directed toward restricting production in order to reduce the oversupply. An interesting and constructive suggestion, made by a large producer, is that the copper industry itself undertake to stockpile metal in periods of reduced demand. This procedure would represent a departure from reliance on the Government to soak up excess supplies (which actually resulted from U. S. Government incentives under the Defense Production Act).

Our guess is that the major copper producers will soon initiate a broad plan of voluntary curtailment of copper production in order to prevent copper prices from decreasing any further. In fact, U.S. and African producers have already announced such plans. And although Chilean producers are not committing themselves, we feel that they will ultimately fall into line.

The effect of this action on the consumer will be felt only when and if the supply-demand picture becomes balanced. At the moment, supplies are more than adequate and indications are that they will continue to be so for some time to come.

Synthetic fiber production high

Although U.S. production of synthetic fibers in 1957 is about 9% below production last year, world production of synthetic fibers continues to set new records. In contrast, cotton interests indicate that for the last eight years there has been a loss in annual consumption of over one million bales. The decline in cotton use is attributed to Government price controls on raw cotton; synthetics can fluctuate with the market on the basis of supply and demand.

Selenium prices cut

Increases in supply plus competition from other improved materials have forced a general decrease in the price of selenium. Selenium is suffering not only from a drop in TV sales, but from increased use of germanium and silicon rectifiers. As a result, high purity grades have dropped from $15 to $13.50 per lb and commercial grade from $12.00 to $10.50 per lb. This situation of excess supply has led to the removal of U.S. export controls.

U.S. Steel sets pace for producers as . . .

Price of Steel Jumps Average of $6 per Ton

■ The fact that U.S. Steel Corp. initiated a $6 per ton general increase in the price of steel last month came as no surprise to anyone who was familiar with the steel industry's labor contracts. The increase had been predicted as far back as last January. The only note of surprise concerning the entire matter was registered by another steel company — and for a different reason. Avery C. Adams, president of Jones & Laughlin Steel Corp., said "the announced price increase is grossly inadequate insofar as covering our total anticipated cost increases is concerned."

The price increase is directly attributable to contracts written with the United Steelworkers Union which stipulated automatic wage increases for some 700,000 workers. The increased cost of labor is estimated by the steel industry to be 21¢ per hr, or approximately 6%. The price rise is given as approximately 4%.

The new prices

With the new increases, the average price of U.S. Steel's carbon and alloy steel products is up to $155 per ton—an increase of about 7¾¢ per lb. The increase on carbon steel products, which make up the bulk of steel tonnage, ranges from $3.50 per ton for semifinished steel or re-rolling quality to $10.50 per ton for track spikes. Other products affected were: standard structural shapes, up $5.50 per ton; plates, up $5.00 per ton; standard bars, up $7.00 per ton; hot rolled sheets, up $5.00 per ton; and cold rolled sheets, up $5.00 per ton. (See accompanying table and the price charts on the following page for further details.)

Stainless steel base mill prices and extras were also increased about 4%, but no details were available at press time.

OLD AND NEW PRICES FOR SPECIFIC STEEL PRODUCTS[a]

Product ↓	New Price	Old Price	Increase
CARBON STEEL			
Blooms, billets, slabs (forging)	96.00	91.50	4.50
Blooms, billets, slabs (rerolling)	77.50	74.00	3.50
Tube rounds	117.50	111.50	6.00
Skelp	97.50	92.50	5.00
Standard bars, small shapes	115.50	108.50	7.00
Cold finished bars	146.00	137.00	9.00
Concrete reinforcing bars	108.50	101.50	7.00
Standard structural shapes	105.50	100.00	5.50
Bearing piles, CBP sections	105.50	100.00	5.50
Sheet piling	124.50	118.00	6.50
Plates	102.00	97.00	5.00
Floor plates	123.50	118.50	5.00
Light rails	130.00	125.00	5.00
Tie plates	132.00	125.50	6.50
Joint bars for stand rails	139.50	132.00	7.50
Track spikes	195.00	184.50	10.50
Axles	175.50	167.00	8.50
Hot rolled strip	98.50	93.50	5.00
Hot rolled sheet 18 gage and up	98.50	93.50	5.00
Cold rolled sheets	121.00	115.00	6.00
Galvanized sheets	132.00	126.00	6.00
Long terne sheets	140.00	134.00	6.00
Electrical sheets, electric grade hot rolled, cut length, 22 gage	236.00	220.00	16.00
HIGH STRENGTH STEEL (Cor-Ten)			
Standard structural shapes	155.00	147.00	8.00
Plates	152.50	145.00	7.50
Bars, small shapes	158.50	148.50	10.00
Hot rolled sheets	145.50	138.00	7.50
Galvanized sheets	194.50	185.50	9.00
Cold rolled sheets	179.50	170.50	9.00
Hot rolled strip	146.50	139.00	7.50
HIGH STRENGTH STEEL (Man-Ten-R)			
Standard structural shapes (incl CB sections)	130.50	125.00	5.50
Plates	128.00	123.00	5.00
Bars, small shapes	133.50	122.50	11.00
Hot rolled sheets	121.50	116.50	5.00
HIGH STRENGTH STEEL (Man-Ten-S)			
Standard structural shapes (incl CB sections)	139.50	134.00	5.50
Plates	137.00	132.00	5.00
Bars, small shapes	142.50	131.50	11.00
Hot rolled sheets	130.50	125.50	5.00
Hot rolled strip	130.50	125.50	5.00
ABRASION RESISTING STEEL			
Plates	135.00	125.00	10.00
Bars, small shapes	143.50	129.50	14.00
Hot rolled sheets	132.50	122.50	10.00
Hot rolled strip	132.50	122.50	10.00
ALLOY STEEL			
Ingots	77.00	74.00	3.00
Blooms, billets, slabs	114.00	107.00	7.00
Hot rolled bars	129.50	122.50	7.00
Bar shapes, structural shapes	131.00	124.00	7.00
Plates	144.00	137.00	7.00
Hot rolled strip, and sheet	162.00	155.00	7.00

[a]Given in $ per ton.

Prices of Materials

Changes since last month are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.44-.54
Butadiene-Styrene	.17- 30	.26-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	47-1	.70-.92
Natural	.33[b]	—

[a]Less than carload quantities.
[b]Average spot price for month of April.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd. 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a]Price includes binder or finish.
[b]Price varies with binder.
[c]0.010-0.020 in. thick

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod ⅛-¼ in.	Rod ⅜-1¼ in.	Tube ⅛-¼ in.	Tube ⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13		13	
Nylon	1.35-2.30	—	3		3	
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.27-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb. except where indicated

ALUMINUM

Pig (99-99.9%)	.25-.27
Ingot (99-99.9%)	.27-.29
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-.03 in.)[a]	.40-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.45	.47	.48
Seamless Tubing	.48	.50	.51
Rod (not f.c.)	.44	.47	.48
Wire	.45	.48	.49

COPPER

Ingot (elec)	.29
Sheet, Strip (hot rolled)	.51
Seamless Tubing	.52
Rod, Drawn	.49
Rod, Free Cutting	.58
Wire	
Round	.35
Square, Rectangular	.38
Magnet	.42

LEAD

Common Grade	.14

MAGNESIUM

Pig (98.8%)	.36
Ingot (98.8%)	.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN

Primary[a]	.97

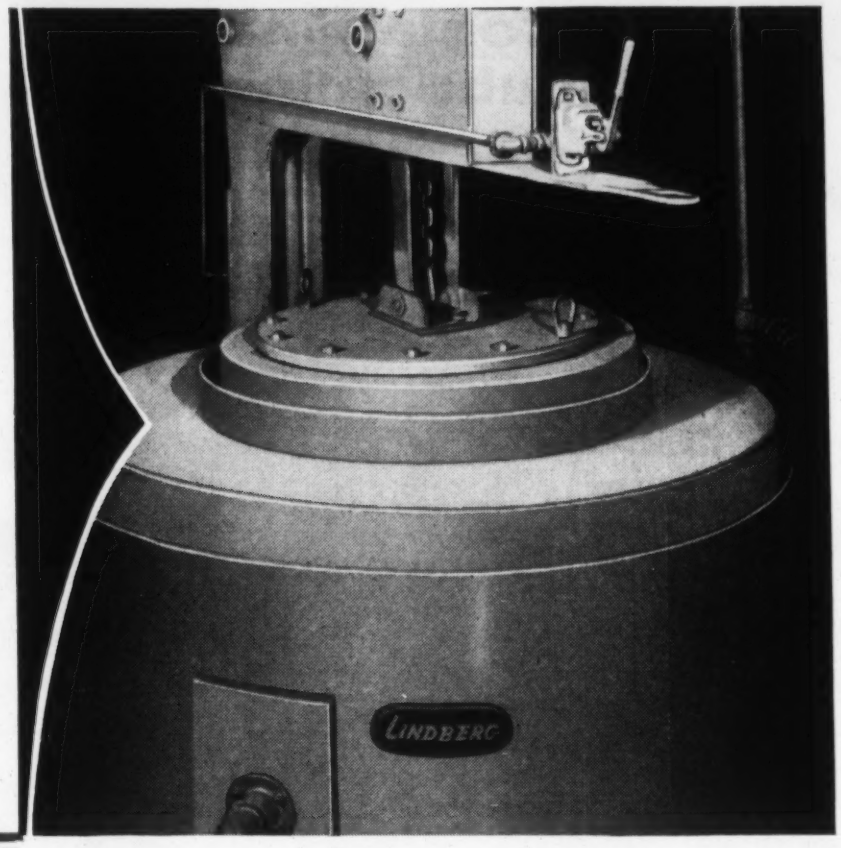
[a]Delivered price.

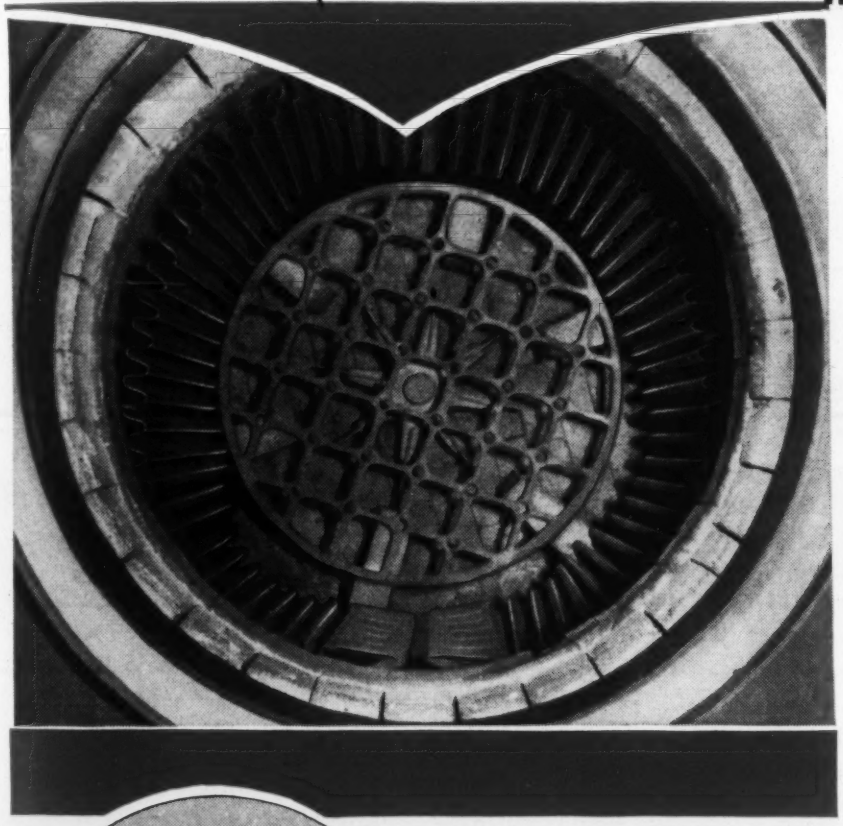
(continued on p 20

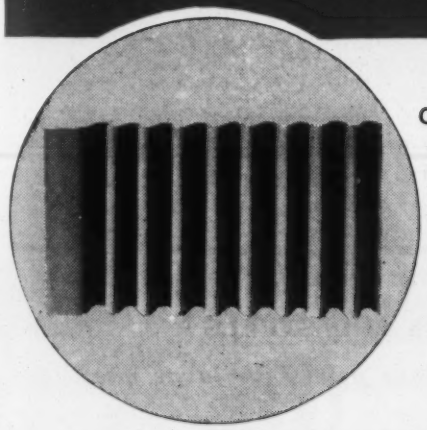
FROM THE OUTSIDE

. . . JUST ANOTHER LINDBERG PIT-TYPE CARBURIZING FURNACE

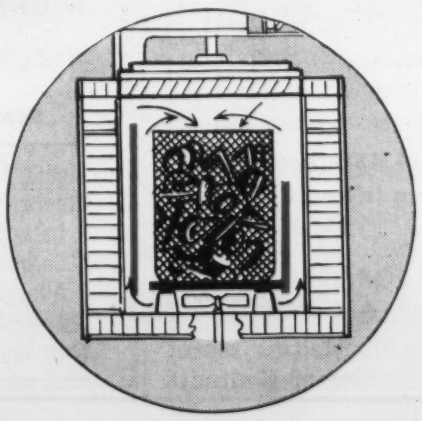
BUT LOOK INSIDE







CORRTHERM elements operate on extremely low voltage. No leakage through carbon saturation. Shock or short hazards eliminated. No complicated mountings required. An exclusive Lindberg development.



Note how CORRTHERM elements serve as baffles to direct forced convection streams through the charge.

No Retort!

Because it needs no retort, this new Lindberg electric vertical pit-type furnace gives you these important advantages:

- **Lower initial cost, no retort to pay for.**
- **No expensive retort replacement.**
- **Downtime for retort replacement eliminated.**
- **Increased production because it heats faster.**
- **Exact atmosphere control maintains work quality.**
- **Versatile, carbon-diffusing and requenching along with carburizing. Adaptable to variety of work.'**

All this is made possible by Lindberg's new CORRTHERM electric heating element. For lower initial cost, lower maintenance costs, faster production, better quality control, why not look into this furnace. It's additional evidence that, if you're concerned with the application of heat to industry, better talk it over with Lindberg.

LINDBERG
ENGINEERING COMPANY

2451 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 S. Regentview Ave., at Downey, Calif.
Toronto Plant: EFCO-Lindberg, Ltd., 11 Front Street, East

For more information, turn to Reader Service card, circle No. 544

Non-Contaminating!
Self-Lubricating!

—SPECIFY

morganite

SELF-LUBRICATING

CARBON PISTON RINGS and ROD PACKINGS

. . . for non-lubricated compressors

Eliminates lubrication problems in compressors where contamination cannot be tolerated. The inherent lubricating property of Morganite, plus ability to polish and glaze compensating surfaces, assure friction minimizing operation. A corrosion resistant film imparted to opposing metal surfaces prevents scoring . . . reduces maintenance and replacement.

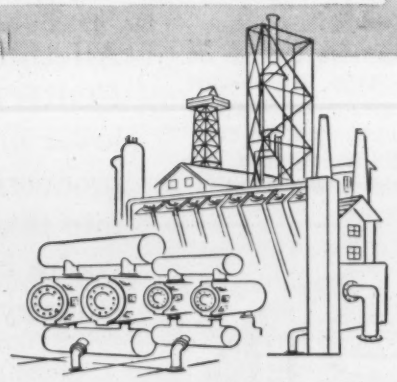
CARBON GLAND RINGS

. . . for high sealing efficiency

For trouble-free operation in turbines, compressors, blowers, fans.

These high efficiency pressure and vacuum seals for steam turbines can be safely mounted with less clearance than metallic rings. Unaffected by axial movement of shaft, accommodate considerable radial shaft displacement with no danger of seizure or loss of efficiency.

Specify Morganite! For sealed mechanisms, inaccessible locations or where contamination is a problem—Morganite Self Lubricating Bearings, Valve Components, Slides, Seal Noses and Pump Vanes are available. Write for complete details and literature, now!



Morganite INCORPORATED

TRADE MARK

3324 48th Avenue
Long Island City 1
New York

. . . FOR OVER HALF A CENTURY

Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

For more information, turn to Reader Service card, circle No. 443

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	2.00-2.50
Bars, Rod	6.15-6.40
Plate	8.00-10.75
Sheet, Strip	9.50-11.10
Wire	7.50-8.00

ZINC

Primary[a]	.10½[c]
Die Casting Alloys[b]	.15-.16
Sheet	.24
Ribbon	.21
Plates	.19

[a]Prime Western—Special High Grade. [b]Alloys 2, 3, 5. [c]Delivered price.

METAL POWDERS

Aluminum [a,b]	.36
Brass [a]	.34-.43
Copper (elec or red.)[a]	.43
Columbium	120
Molybdenum (98%)	3.80-4.10
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34[a]
Palladium	$23-24/troy oz
Platinum	$92-95/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a]Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	77
Billets, Blooms, Slabs	
Carbon, Re-Rolling	77.50
Carbon, Forging	96
Alloy, Forging	114
Seamless Tube Rounds	117.50
Wire Rods	$6.15 cwt

(continued on p 210)

UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic.....Organic.....Decorative.....Protective

Simple bronze plating process gives gold-like finish

- ***M&T copper-tin process deposits extraordinary, golden-glow decorative plate . . .***
- ***Also cuts need for nickel as undercoat***

BRONZE plating has proved itself a practical finish in large and small installations. The copper-tin process developed by Metal & Thermit eliminates usual difficulties and disadvantages in alloy plating. It is as easy to operate and control as normal processes depositing a single metal.

Equally important, this bronze can be deposited with brilliant 24K gold color by using a trouble-free brightener. Protected with a clear organic coating, it provides a high quality decorative finish with unusual appeal and long life. Overall cost of this bronze rivals that of copper and is less than that of a brass plate.

M&T Bronze gets the trophies. Golden-glow finish for die cast trophy cups wins over copper-nickel-gold formerly used by leading producer.

VALUABLE UNDERCOAT

As an undercoat, M&T Bronze has these qualifications: Good corrosion resistance; hardness better than copper and virtually equal to nickel; more ductility than nickel.

Undercoat-bronze can be plated semi-bright or matte. Both buff more readily than copper and with less chance of cut-through on edges.

OPERATIONAL ADVANTAGES

M&T Bronze offers better than twice the speed of fast copper plating solutions. There are numerous installations working at normal current densities of 60-75 amps per sq. ft. Densities of 100 amperes deposit over one-tenth mil a minute smoothly.

Golden-glow bronze delivers uniform color on intricate decorative work. So outstanding is its throwing power, it is being used to replace copper on complex automobile parts. It uses single anode circuits, and copper anodes which corrode uniformly. The tin is supplied by potassium stannate additions, assuring simple, economical control of the process.

For an unusual finish, both in appearance and protective function, the golden-glow M&T Bronze Process offers interesting possibilities to metal finishers and designers. Send for data.

New economy in chromate finishing

Several newly developed Unichrome Dip Compounds work at extreme dilutions. They offer chromate solutions with still lower make-up and operating costs than previously delivered by economical Unichrome Dips. These new Dips make it practical to preserve shelf life and appearance of galvanized, zinc plated or die cast items, even those having low unit price or narrow margin of profit.

MATCHED TO THE NEED

Unichrome Dip Solutions form corrosion-resistant finishes integral with zinc, improve and protect its eye appeal.

But chromate dips are active solutions which strip away zinc as well as convert its surface into an attractive but inactive film. As a result, the type of equipment used and the operating time or cycle affect results. The differing needs of manual or automatic finishing must be satisfied to produce the color, corrosion resistance, uniformity of finish—as well as the economy desired. Since no single chromate solution is equally suitable for all applications, many specialized Unichrome Dip Compounds are made available.

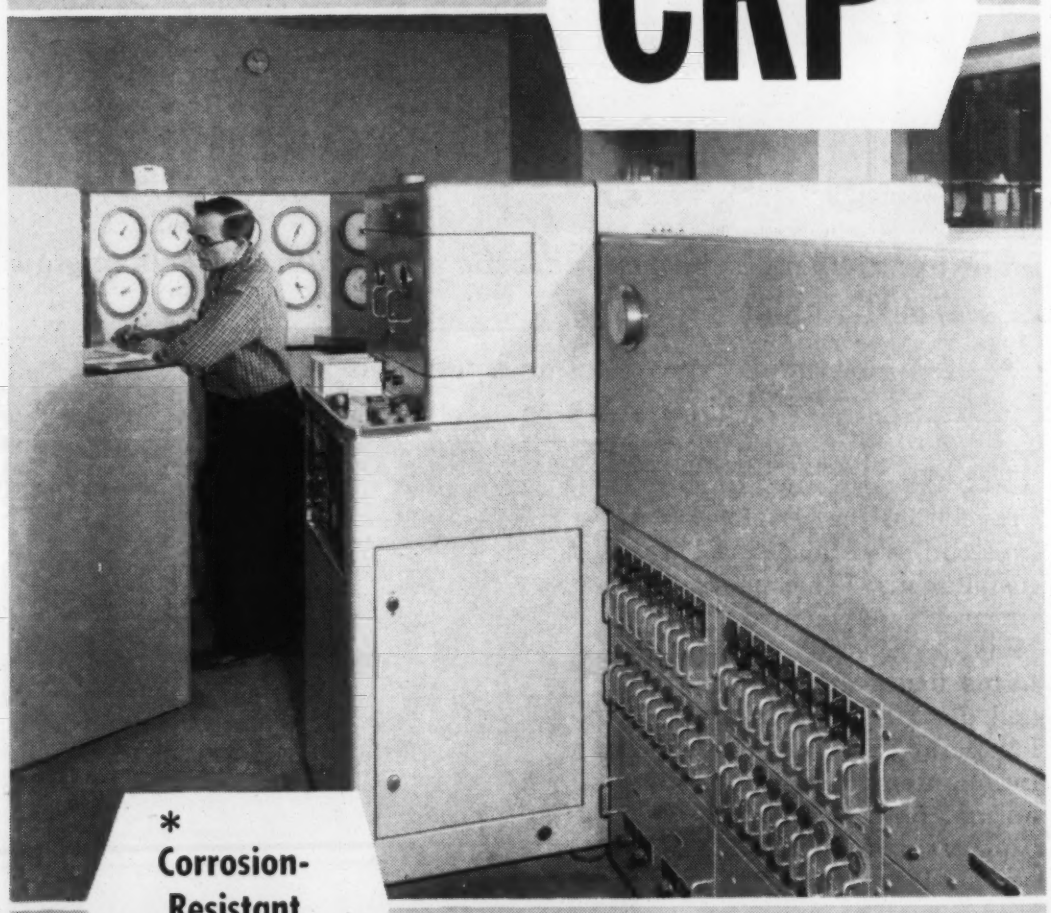
Metal & Thermit will gladly recommend the proper dip to meet specific needs. Simply submit details of product and requirements.

Unichrome is a trademark of Metal & Thermit Corp.

METAL & THERMIT
CORPORATION

General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, Ont.

Here's the Most Modern Control Equipment to Protect Your Product from CRP*



* Corrosion-Resistant Problems

This spectrometer in the WAUKESHA Metallurgical Laboratory provides the most positive assurance that *your* corrosion-resistant castings correspond exactly to the specified formula . . .

Every heat is checked and so quickly can spectrometer readings be obtained that any correction can be made in the foundry *before the metal is poured.*

There is simply *no* guesswork when WAUKESHA FOUNDRY Company is entrusted with your corrosion-resistant castings.

If you have corrosion-resistant problems* or difficulty in obtaining pit-free, uniform, free-machining castings in a production run — turn your troubles over to WAUKESHA — for WAUKESHA has one of the finest metallurgical laboratories in the industry . . . Naturally, not a bit of obligation. Why not write today?

WAUKESHA FOUNDRY COMPANY

5704 Lincoln Avenue • Waukesha, Wis.

For more information, turn to Reader Service card, circle No. 538

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.10	7.62	7.20
Sheet, H.R.	4.92	7.27	—
Sheet, C.R.	6.05	8.97	—
Strip, H.R.	4.92	7.32	8.10
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.42	7.92	6.47
Bar, C.F.	7.30	—	8.77

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.46-.51	.51-.59
321[a]	.47	.56	.60	.66
347[a]	.56	.65	.70	.80
Martensitic				
410[a]	.28	.34	.35	.40
416	.29	.34	.35	.47
403	.32	.38	.40	.48
420, 440	.34	.41	.45	.62
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.36-.38	.41-.47
442	.32	.38	.40	.56
431	.30	.35	.46	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.37	.43	.45	.49
Extra Low C				
304L	.48	.56	.59	.63
316L	.64	.74	.78	.82
Precip Hard.				
17-17PH	.55	.65	.72	.77-.82

[a]Ingot prices approx 60% of forging billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.34
Stainless Steel	
304	1.08
316	1.44

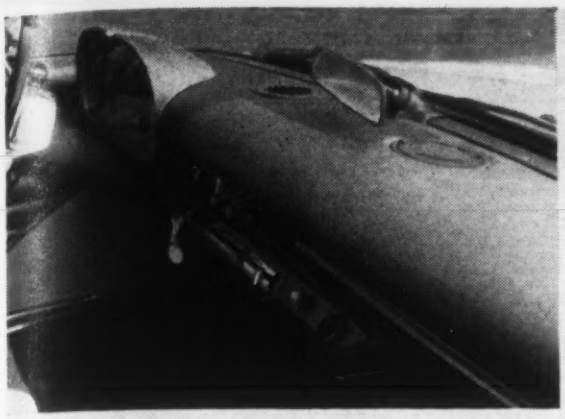
[a]Price for —100 mesh.

IRON ($/gross ton)

Pig	65-66

(continued on p 212)

NEW WAY TO UPGRADE YOUR PRODUCTS: VINYL COATINGS



Pleasant-to-touch, glare-reducing dashboard finished with a vinyl dispersion that *creates its own patterns.*

For "leather-like" coverings for metal desk, file cabinets, and office appointments . . .

For stamped, light-metal luggage; instrument cases; office-machine housings . . .

Thin, leathery, "textured" finishes for metal

Something new in metal finishing: leather-like, warm-to-the-touch finishes that heat-cure to a textured finish. It's actually "texture in paint!" The base material: abrasion-resistant vinyl (of hard-wearing floor-tile fame) formulated as a dispersion for spray or dip coating. A single coat provides the complete finish. You can specify any shade or tone of color.

Short heat-cure at moderate temperatures adheres the vinyl permanently to the metal. These vinyl-dispersion finishes are so flexible, adhere so tenaciously, that prefinished sheet metal can be stamped to shape without need for final finishing.

Write for sources of vinyl in liquid form for coating metal, glass, or wood. Get a head start on investigating the profitable ways to use these new, textured, leathery finishes. Write today!

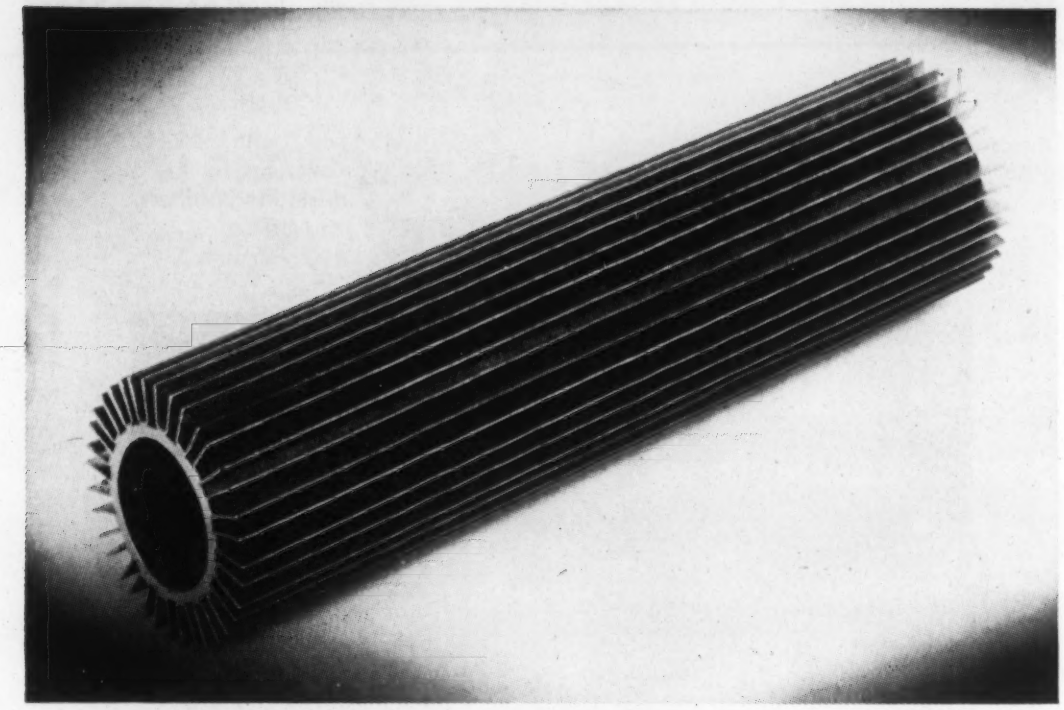
Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
Dept. SP-2, St. Louis 1, Missouri

Monsanto manufactures a wide variety of plasticizers and Opalon® resins for formulators of these high-quality vinyl dispersions.

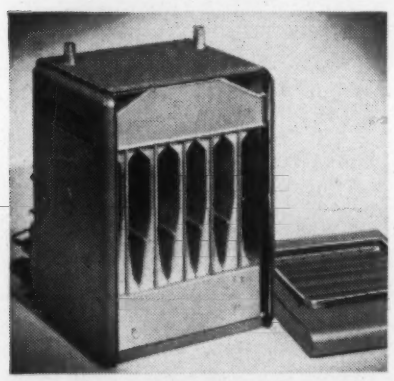
MONSANTO®

Where Creative Chemistry Works Wonders for You

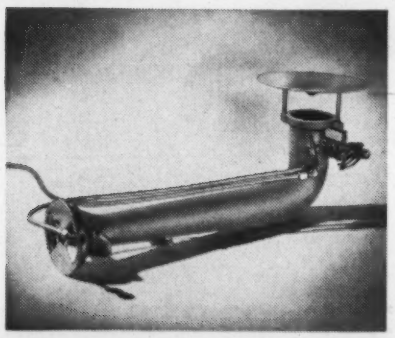
For more information, turn to Reader Service card, circle No. 432



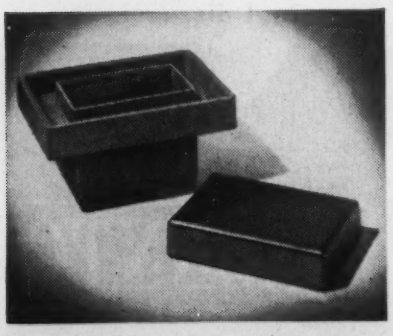
Heat exchanger used in evaporators and condensers will withstand 1600° F indefinitely.



Stainless Alloy Surface protects heat exchanger element in gas-fired unit heater which operates at approximately 1600° F.



Stainless Alloy Surfaced flame spreader replaces Stainless Steel spreader normally used in fuel burner nozzle at a 40% cost saving.



Heat treatment retorts operating up to 2600° F can be protected against heavy oxidation which reduces service life.

Heat Protection

Up to 2600° F.

Steels having a carbon content from 1008 to 1053 can now be given a *Stainless Alloy Surface* providing heat resistance equal to that afforded by Stainless Steels. A new, low-cost process — ASC Metal Diffusion — creates by atom interchange a chromium-rich surface that gives unlimited heat protection at 1600° F. and limited protection up to 2600° F.

Unlike coatings, platings and claddings, an ASC Stainless Alloy Surface becomes an integral part of the processed work. It will not chip, peel, craze or crack. The Process is applicable to all iron, steel, and ferrous alloys — and forming, welding, brazing and soldering, can be done by methods in general use.

ASC Metal Diffusion also gives low and medium carbon ferrous products *corrosion* resistance equal to that of 430 stainless. Medium and high carbon content products can be given *wear* resistance surface hardness of RC 70-72. For more information about this revolutionary process write for data, consultation, or product demonstration.

ALLOY SURFACES COMPANY

103 South Justison St., Wilmington 1, Del.

For more information, turn to Reader Service card, circle No. 519

PRICES AND SUPPLY

TINPLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75-9.40
Black Plate	7.85-7.95

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.50
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.50
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.00
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.50
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.50
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.50
Vinyl	1.0	2.0	2.50
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a] Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b] Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

Production and Use of Metals to Increase

Increased use and production of metals will continue in proportion to the nation's increasing population and national income, according to Felix Wormser, assistant secretary, Dept. of the Interior.

Speaking at the recent conven-

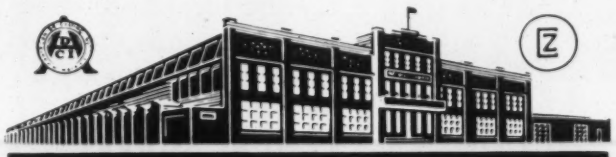
CASE HISTORIES FROM
MT. VERNON FILES

"Brain" stops new Electrolux automatically!

The minute this new Automatic Electrolux Cleaner has absorbed so much dirt it can no longer operate at high efficiency, it stops and the cover pops open. Replacing the sealed paper dust bag with a new one sets it up for further operation. It is one of several exclusive Electrolux features which includes 20% greater suction power than any machine the company has ever made. This is due in part to the increased speed and power of its electric motor.

The additional power and the automatic features of this new cleaner were not, however, achieved at the expense of added weight, because it is remarkably light for an appliance of such power and flexibility. By using die castings for the motor frame, elbow and adapter, both weight and manufacturing costs were kept down. As you can see these parts are complex. The motor frame alone, for example, involves apertures of various sizes and shapes, lugs, curved members, straight members, flanges, fillets, vanes and shoulders all combined into a very lightweight yet extremely rigid, strong unit. The other parts, although smaller, are also "toughies". But die casting is the most economical method of producing these intricate parts which combine strength with light weight and holding to such close tolerances that little or no machining is reqiured to finish them.

Mt. Vernon can help you make the most of these and other die casting advantages by a complete four-fold service of: (a) consultation—to help with design and production problems; (b) die making—on modern tool and die equipment handled by skilled personnel; (c) castings—aluminum and zinc, guaranteed "on grade" at all times; (d) machining facilities—for handling any machining operations your castings may require. As in the case of Electrolux, a switch to die castings may profit you tremendously. Let's talk it over.



MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

SALES REPRESENTATIVES

Mr. Grant Eller
6 East 194th St., Cleveland, Ohio

Mr. Jerome J. Theobold
9 East Genesee St., Skaneateles, N. Y.

Mr. Anker Anderson
Cascade Road, Stamford, Connecticut

Mr. William Sauers
101 Briarcliff Road, Rochester, N. Y.

Mr. David H. King
75 Willow Street, Guilderland, N. Y.

Mr. George E. Hahl
39 South Munn Ave., East Orange, N. J.

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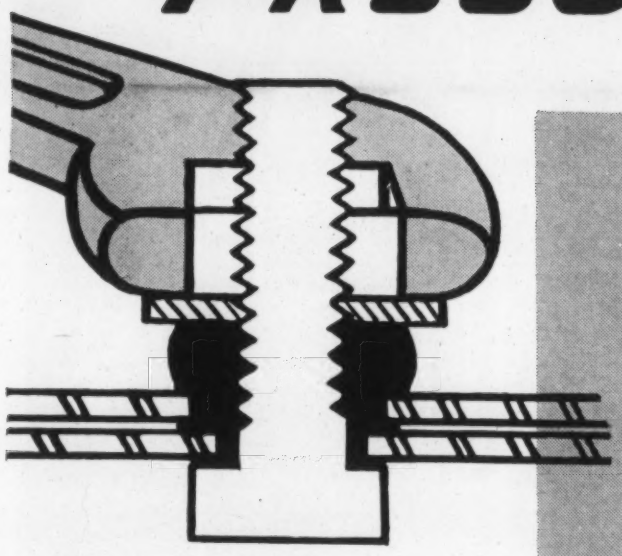
PRESSTITE

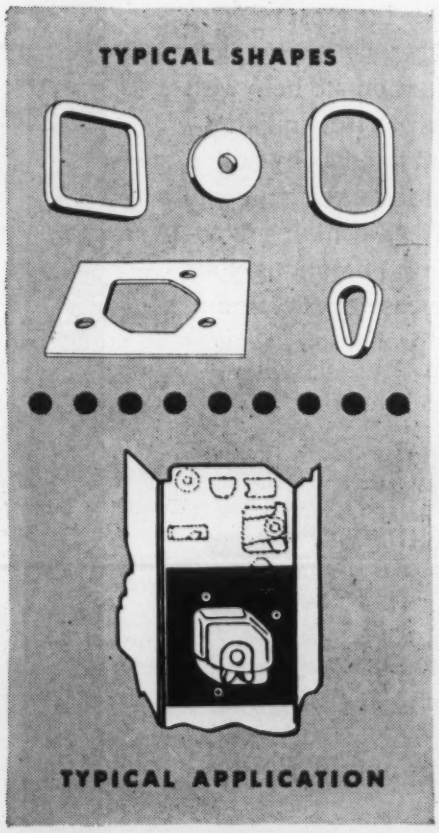


mastic gaskets and washers

Can Improve your product

and Speed-Up production

THEY "COLD-FLOW" UNDER PRESSURE



Under pressure, Presstite mastic gaskets and washers flow into any annular space or void made available. The result: a positive, close-fitting seal against water, dust, air, etc.—never possible before with so little time, effort and cost. Perfect to seal around bolts, screws, fasteners of all kinds.

Flow is controlled by amount of material in washer or gasket, which is predetermined to fit your job.

Can be furnished in materials that resist petroleum, gasoline, aviation fuels and many other solvents.

TYPICAL SHAPES . . . Many stock sizes available, plus special shapes for specific applications.

TYPICAL APPLICATION . . . Thin mastic gasket to seal automobile door latch assembly.

PRESSTITE SEALING COMPOUNDS — **PRESSTITE-KEYSTONE ENGINEERING PRODUCTS COMPANY** — KAP

A Division of AMERICAN-MARIETTA COMPANY
3916 CHOUTEAU AVENUE, ST. LOUIS 10, MISSOURI

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tion of the Assn. of State Development Agencies, Mr. Wormser pointed out that "titanium has already increased to sixth place in value in primary metal production. By the end of 1975 the value of domestic production in this metal will probably have passed lead and zinc, although actual production in tonnage is not likely to exceed either of these metals."

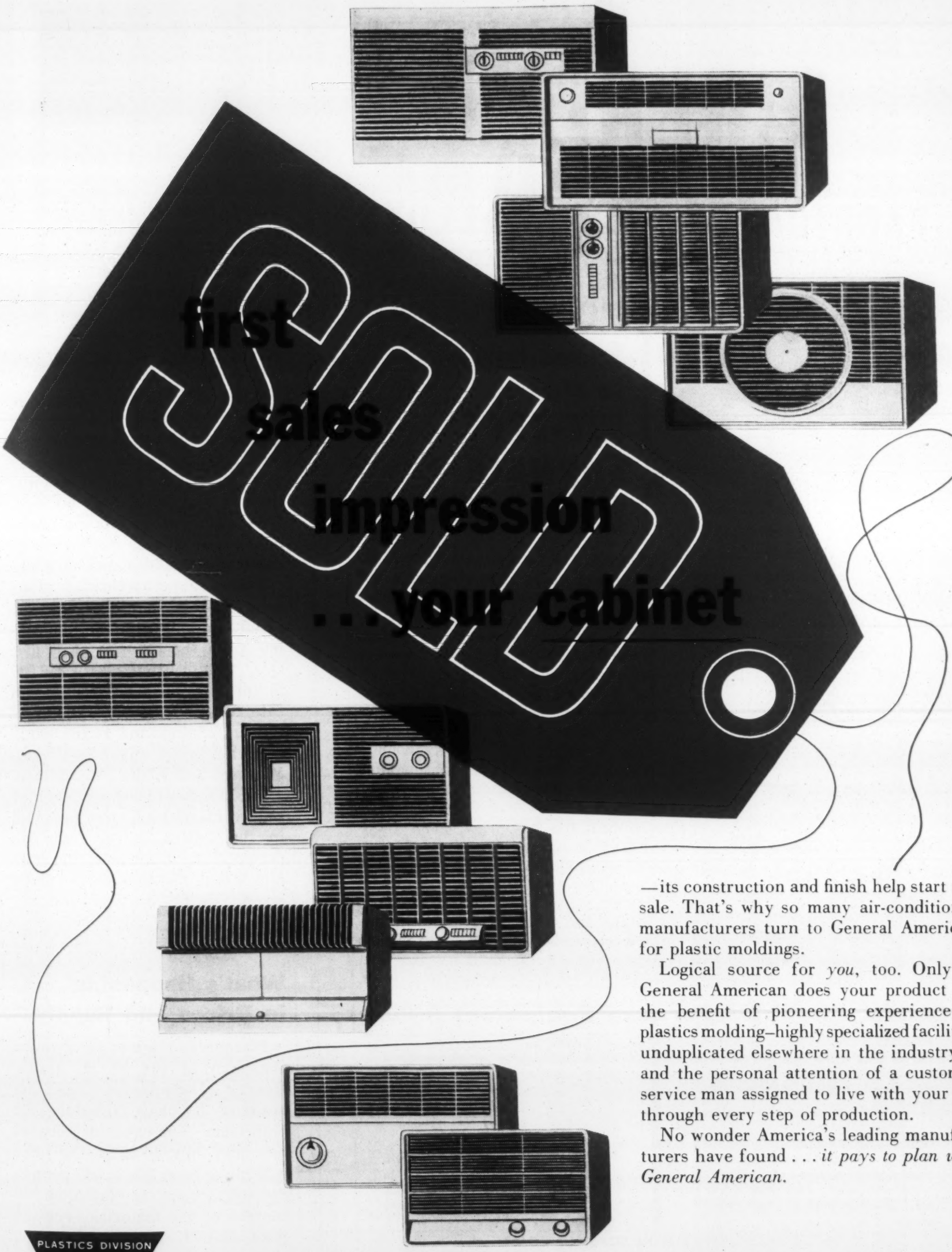
Consumption of aluminum has been increasing at three times the growth of real income, Mr. Wormser said. He predicted, however, that its growth rate will probably slow down within the next two decades.

Mr. Wormser said iron ore consumption by 1975 will increase between 15 and 25% throughout the world, but he predicted that U. S. production will do well to hold its own. Consumption of lead, copper and zinc will also continue to grow. Zirconium and beryllium are growing in importance as construction materials, and lithium and boron, because of their light weight, appear to have great promise for increased use during the next decade.

Mr. Wormser pointed out that the consumption of precious metals and minor base metals has grown with real income and will continue to grow. However, he doubted whether there would be much expansion in the production of gold and silver, which he said is now at the level of the 1930's.

Nickel Production, Use Continue to Rise

Free world mine production of nickel in 1956 increased for the sixth consecutive year to establish a new high of approximately 231,000 short tons, according to the Bureau of Mines. Of the 1956 total, Canada produced about 77%, Cuba 7%, and the United States 3%. However, despite the diver-



—its construction and finish help start the sale. That's why so many air-conditioner manufacturers turn to General American for plastic moldings.

Logical source for *you*, too. Only at General American does your product get the benefit of pioneering experience in plastics molding–highly specialized facilities unduplicated elsewhere in the industry—and the personal attention of a customer service man assigned to live with your job through every step of production.

No wonder America's leading manufacturers have found . . . *it pays to plan with General American.*

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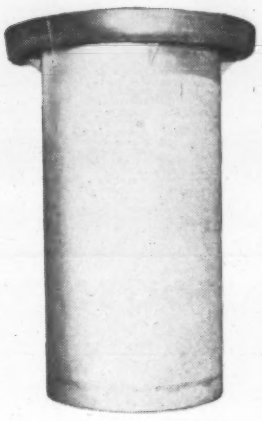
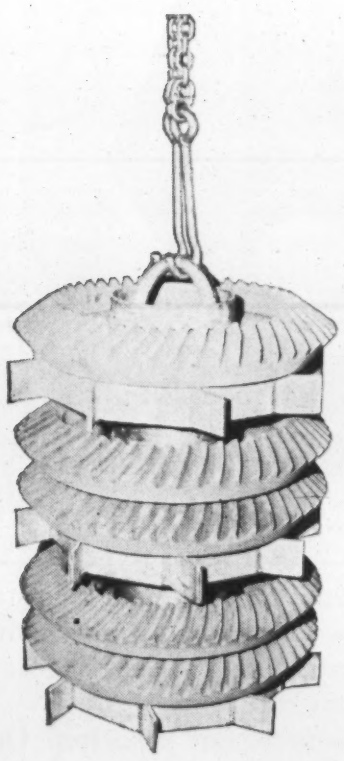
ROLOCK

FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT



ROLOCK knows how to step up PIT-TYPE FURNACE EFFICIENCY



This BIG welded-fabricated fixture for processing heavy duty ring gears 28" in diameter is just an example of many hundreds of lift post fixtures built for use in pit-type furnaces. This fixture is held to 1670° F. for 12 hours in carburizing, then cooled to 1450° F. for 4 hours, then slowly air-cooled. It takes the place of a heavy casting.

Not only is this design relatively light in weight and hence economical in furnace time and fuel consumption, but it has proved exceptionally stable under the heavy load.

Rolock has become a major fabricator of a full range of pit-type furnace equipment adapted to the service requirements of all leading furnace makes . . . simply because Rolock designs and welded-fabrication know-how consistently reduce costs and help step up efficiency. Send us your next order for recommendations and quote.

ROLOCK Pit-Type Furnace Equipment *includes*:

RETORTS
All sizes and for all makes of furnaces; incorporating ROLOCK's time-tested quality methods of fabrication.

GRIDS and SCREENS
Screens available immediately from stock in a range of standard sizes and mesh. Also ROLOCK's new pressure-welded, truss-type grids.

BASKETS
A wide range of standardized or special designs, including ROLOCK's new high efficiency "corrugated" construction.

FIXTURES
Often a special fixture will effect tremendous savings in handling parts. Let ROLOCK experience and facilities help you enjoy these economies.

SALES & SERVICE FROM COAST TO COAST
ROLOCK INC., 1282 KINGS HIGHWAY, FAIRFIELD, CONNECTICUT

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

7RL57

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sion to industry of 77.5 million pounds from scheduled shipments to the Government stockpile, the shortage of nickel for civilian needs continued in 1956.

Total consumption of nickel in 1956 was 127,578 short tons, 17,478 tons more than was consumed in 1955. Of the total, 39% was utilized in stainless and engineering alloy steels. Usage of nickel in stainless steel was 24% higher in 1956 than in 1955, but was 8% lower in engineering alloy steels. More nickel was also used in cast irons, high temperature electrical resistance alloys, nonferrous alloys, electroplating, catalysts, ceramics and magnets.

Domestic production of nickel established a new high in 1956, chiefly as a result of greater output from the deposits at Riddle, Ore. Total output was 1,246,000 lb (nickel content) of refined sulfate recovered as a by-product of copper refining, and 14,784,000 lb of nickel in ore mined in Oregon, Missouri and Idaho. In addition, 4,342,000 lb (nickel content) of refined nickel salts were produced in the United States from imported crude nickel salts and from nickel shot, nickel oxide and nickel scrap.

What's Happening in Prices and Supply

Plutonium—Lewis L. Strauss, chairman of the U. S. Atomic Energy Commission, has announced a price schedule for plutonium. For purchase between now and July 1, 1962, the price will range from $30 to $45 per gm, depending upon the plutonium 240 content of the material. For the year July 1, 1962, to June 30, 1963, a single price of $30 per gm will be in effect.

Cemented carbides — Prices on cemented carbide dies have been reduced 20% by General Electric

YTTRIUM

Availability of high purity yttrium and rare earth oxides

A report by LINDSAY

Only three years ago, most high purity rare earths were little more than laboratory curiosities.

Today they are extensively used for an amazing variety of chemical and industrial applications.

What happened? Lindsay technicians pioneered the first commercially installed ion exchange unit for the production of separated rare earths. The process was patterned after techniques developed by Doctors Spedding and Powell of the Institute for Atomic Research at Ames, Iowa.

Lindsay's pilot plant rare earth ion exchange installation had 40 six-inch columns. This unit made purified rare earths available to industry for the first time in practical, even though still limited, quantities.

The response from industry was so enthusiastic, we were forced to expand our ion exchange facilities rapidly. Today we have in continuous operation more than 100 columns with large production units of eighteen-inch and sixty-inch diameters.

With our larger production facilities, we are now making prompt shipments of high purity yttrium and rare earth oxides in quantities from a gram to hundreds of pounds.

TYPICAL MAXIMUM IMPURITIES IN LINDSAY PURIFIED RARE EARTH AND YTTRIUM OXIDES

ATOMIC NO.	OXIDE	CODE	PURITY	% RARE EARTH MAXIMUM IMPURITIES AS OXIDES
57	La_2O_3. LANTHANUM OXIDE	528 529	99.99 99.997	0.01 Pr, 0.001 Ce. 0.0025 Pr, 0.0005 others
58	CeO_2. CERIC OXIDE	215 216	99.8 99.9	0.2 (largely La + Pr + Nd). 0.1 (largely La + Pr + Nd).
59	Pr_6O_{11}. PRASEODYMIUM OXIDE	726 729.9	99 99.9	1 La + Nd + smaller amounts of Ce and Sm. 0.1 Ce + Nd.
60	Nd_2O_3. NEODYMIUM OXIDE	628 629 629.9	95 99 99.9	1-4 Pr, 1-4 Sm, 0.5-1 others. 0.1-0.4 Pr + 0.1-0.4 Sm + 0.5 others. 0.1 (largely Pr + Sm).
62	Sm_2O_3. SAMARIUM OXIDE	822 823	99 99.9	0.2-0.7 Gd, 0.2-0.6 Eu, and smaller amounts of others. 0.1 (largely Nd + Gd + Eu).
63	Eu_2O_3. EUROPIUM OXIDE	1012 1011	98-99 99.8	1-2 Sm + smaller amounts of Nd + Gd + others. 0.2 (largely Sm + Gd + Nd).
64	Gd_2O_3. GADOLINIUM OXIDE	928.9 929.9	99 99.9	1 Sm + Eu + trace Tb. 0.1 Sm + Eu + trace Tb.
65	Tb_4O_7. TERBIUM OXIDE	1803 1805	99 99.9	1 Gd + Dy + Y. 0.1 Gd + Dy + Y.
66	Dy_2O_3. DYSPROSIUM OXIDE	1703 1705	99 99.9	1 (largely Ho + Y + Tb + small amounts of others). 0.1 Ho + Y + traces of others.
67	Ho_2O_3. HOLMIUM OXIDE	1603 1605	99 99.9	1 (largely Er + Dy + small amounts of others). 0.1 Er + Dy + traces of others.
68	Er_2O_3. ERBIUM OXIDE	1303 1305	99 99.9	1 Ho + Dy + traces Yb and Y. 0.1 Ho + Tm.
69	Tm_2O_3. THULIUM OXIDE	1405 1403	99.9 99	0.1 Er + Yb + trace Lu. 1 Er + Yb + trace Lu
70	Yb_2O_3. YTTERBIUM OXIDE	1201 1202	99 99.9	1 Er + Tm + trace Lu. 0.1 Tm + trace Lu + Er.
71	Lu_2O_3. LUTETIUM OXIDE	1503 1505	99 99.9	1 Yb + Tm + traces of others. 0.1 Yb + Tm + traces of others.
39	Y_2O_3. YTTRIUM OXIDE	1112 1115 1116	99 99.9 99.9+	1 Dy + Gd + traces Tb and others. 0.1 Dy + Gd + traces Tb Approx. 0.05 Dy + Gd.

COSTS GREATLY REDUCED

Of course, as production of purified rare earths increased, costs came down. For example, only three years ago Terbium Oxide cost $500 a gram. Today you can obtain moderate size lots at less than $3 a gram.

Now that you know these high purity oxides are so readily available and the cost so remarkably low, what are *you* waiting for?

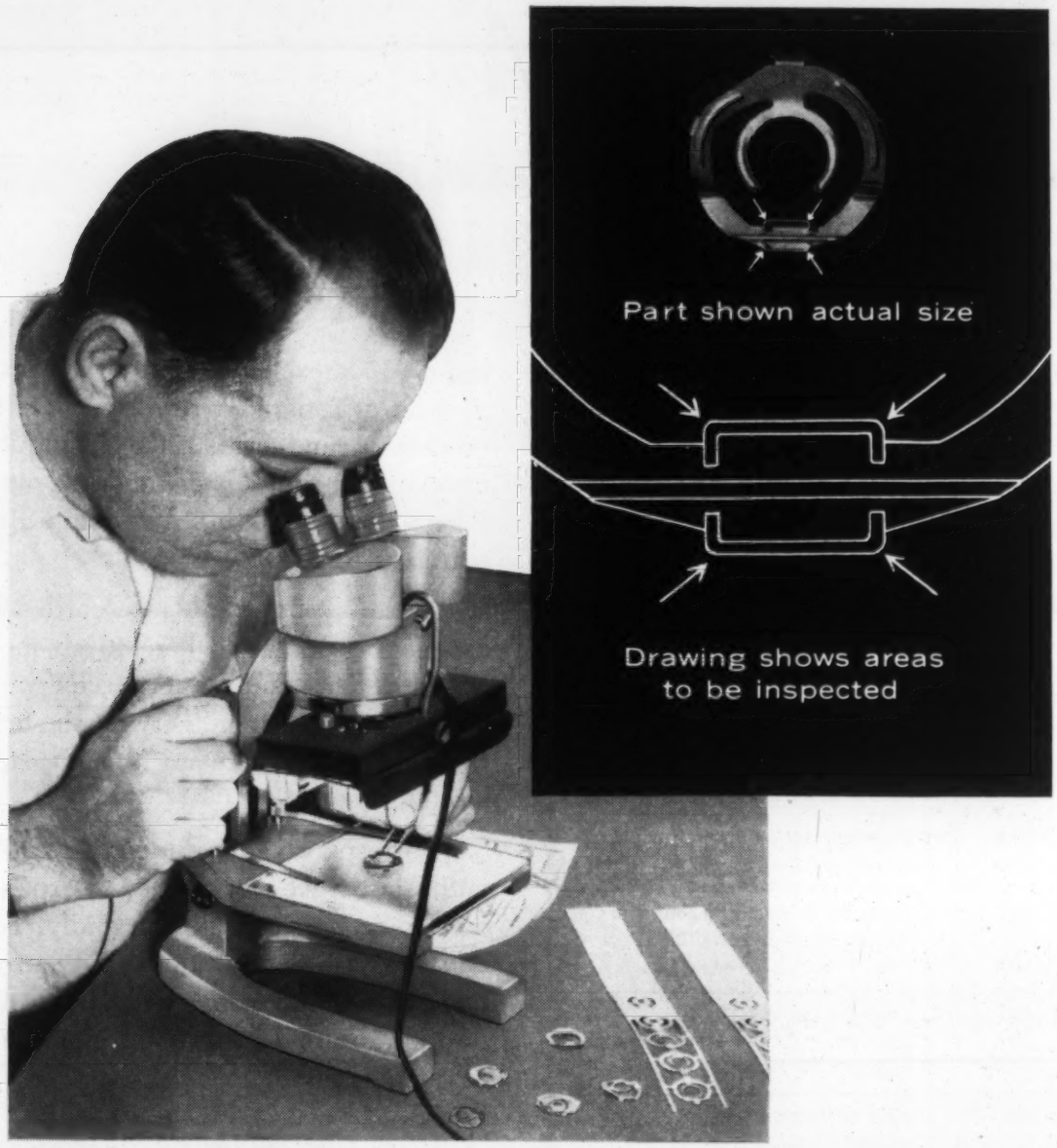
Rare earths, in purities up to 99.99%, have captured the interest and imagination of scientists in many industries as valuable new tools for the improvement of processes and products.

Your research, product development and production people should investigate the possibilities of these materials. Our bulletin "Purified Rare Earth and Yttrium Oxides" will give you detailed information and prices.

PLEASE ADDRESS INQUIRIES TO

LINDSAY CHEMICAL COMPANY

276 ANN STREET • WEST CHICAGO, ILLINOIS



SPENCER

Stereoscopic Microscopes help Allen-Bradley Co. increase production and cut costs

Here's how the Allen-Bradley Company of Milwaukee, Wisconsin applies AO Stereoscopic Microscopes to push the production of potentiometers up, and costly rejects down.

Tiny corners of a metal contact retainer, possible trouble spots, are checked with AO Stereoscopic Microscopes for fractures and flaws. Imperfections at this point allow a graphite button to lose electric contact with a graphite ring. This, in turn, causes an open circuit condition and malfunctions of the potentiometer.

Using an AO Stereoscopic Microscope the operator sees a magnified 3 dimentional image of the part under inspection. Minute defects are immediately visible. Costly failures in the completed instrument are prevented by regular spot checking of component parts.

Like Allen-Bradley, many leading manufacturers use AO-Spencer Stereoscopic Microscopes to solve their small parts inspection problems. These easy-to-use instruments require no lengthy operator training. AO offers America's widest selection of Stereoscopic Microscopes for you to pick exactly the right, most economical instrument for your specific needs.

American Optical Company
INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

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Please send Catalog
on AO Stereoscopic Microscopes.
Name _____
Address _____
City _____ Zone ____ State ____

For more information, turn to Reader Service card, circle No. 488

PRICES AND SUPPLY

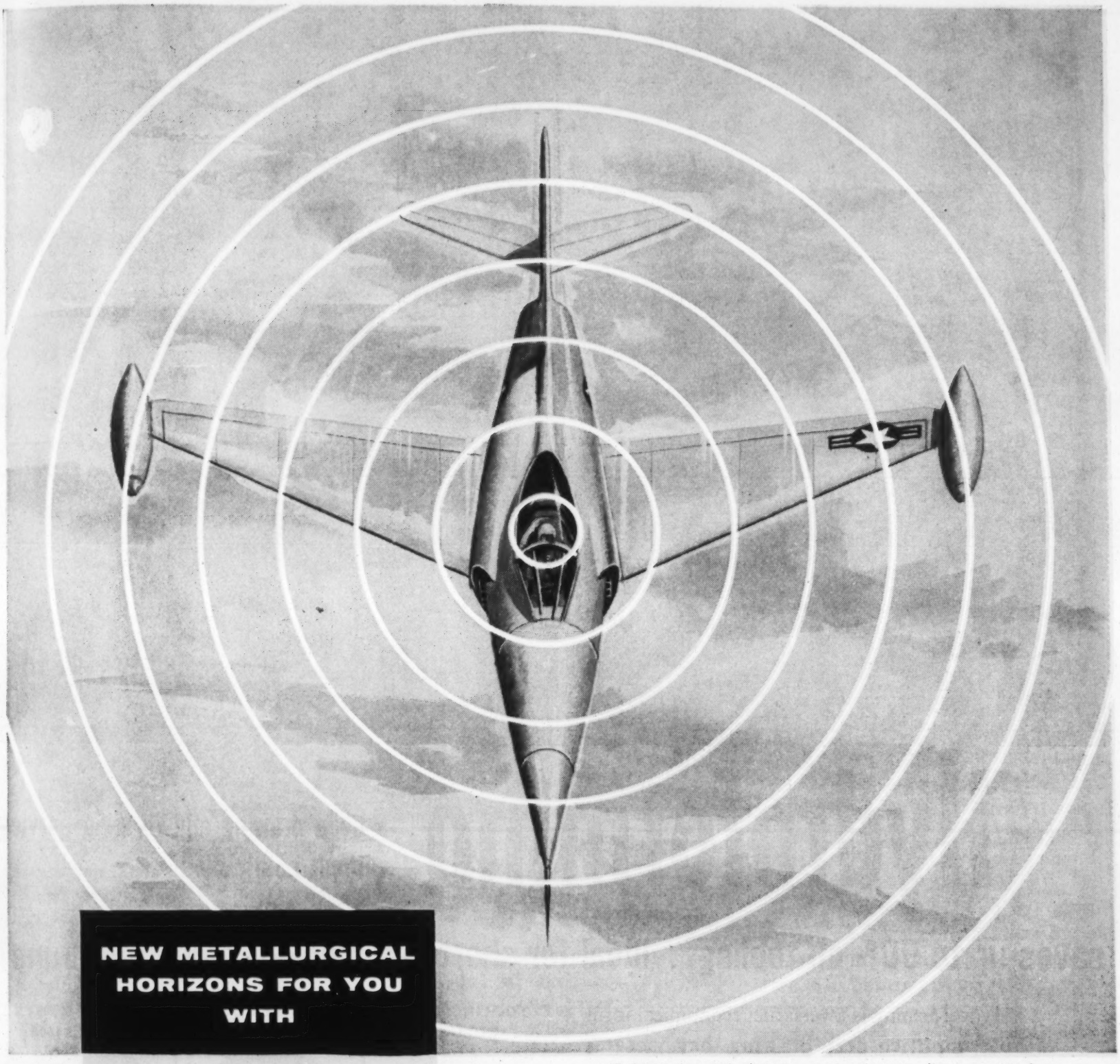
Co. The new prices cover standard Carboloy carbide dies used for wire, bar and tubing operations; in ferrous and nonferrous extruding; and in nail making.

Titanium—Both Du Pont and Titanium Metals Corp. of America have reduced the price of titanium sponge by 50¢ per lb. TMCA's new sponge price is $2.25 per lb. TMCA also says it will complete a 50% expansion of sponge production facilities late this year.

New prices for Du Pont sponge are: grade A-1, cut from $2.75 to $2.25 per lb; grade A-2, cut from $2.50 to $2.00 per lb; and grade A-2 fines, cut from $2.15 to $1.65 per lb. These reductions average approximately 20%.

In addition to the cut in sponge price, Titanium Metals Corp. of America has reduced prices on mill products. Over-all price drop amounts to 10%. Specific price changes are: commercially pure sheet and strip, down $1.50 per lb; plate, down 50¢ to $1.25 per lb; bar, down 95¢ per lb; billets, down 85¢ per lb; and wire, down $1.00 per lb. Extrusions have been decreased about 12%, or about $1.90 per lb. Titanium powder is down $2.00 per lb from $10.00.

Rubber—Consumption of synthetic rubber in the United States during May amounted to 79,710 long tons, establishing the highest ratio to total new rubber used for any monthly period when the use of rubber was not under Government specification control. Synthetic rubber consumption amounted to 63.25% of the total (126,029 long tons). To support this use, a new all-time monthly high of 95,049 long tons of all types of synthetic rubber was produced. A reinforcing silica, Hi-Sil 233, used in rubber manufacture, has been reduced in price by more than 11% by Columbia-Southern Chemical Corp. New price of carload quantities is 8-9¢ per lb.



NEW METALLURGICAL HORIZONS FOR YOU WITH

Elgiloy plays a vital role in the search radar units of our newest jet fighters.

Corrosion Resistant

ELGILOY

as good as gold!

Elgiloy lasts longer . . . resists corrosion, set and fatigue . . . better than the finest steels! This cobalt-chromium-nickel alloy was originally developed for famous Durapower Main Springs in Elgin Watches. Today "the heart that never breaks" is finding wide use for high performance springs, instrument components and other critical industrial applications. In resisting corrosion, Elgiloy is "as good as gold" and superior to the finest stainless steel. Its resistance to set is at least three times as great as carbon steel, its fatigue resistance nearly twice as great. It is non-magnetic. Elgiloy is available in wire, flat strip and bars. It can be blanked stamped, sheared, coiled, formed, welded, brazed, soldered and hardened to Rockwell C58. Write for complete information.

Abrasives Division **ELGIN NATIONAL WATCH COMPANY**

Elgin, Illinois

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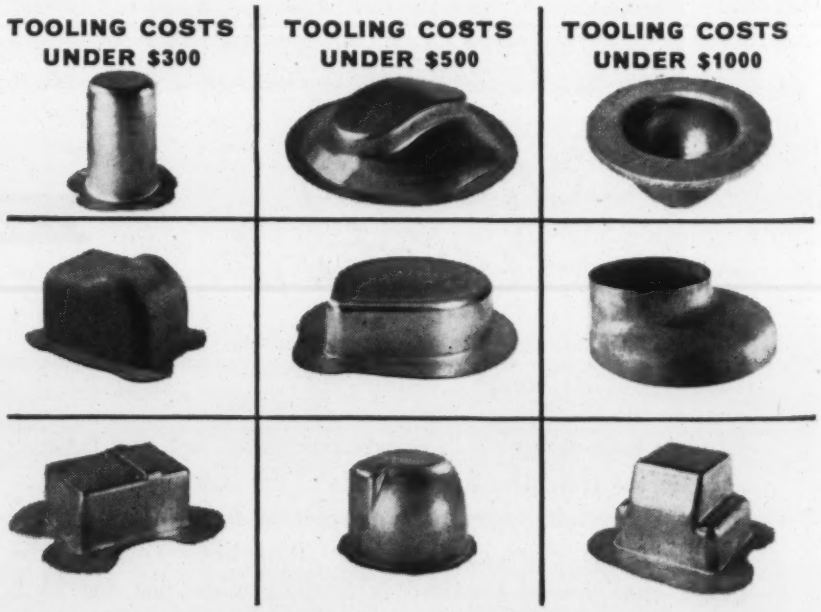
Hydroforming

a deep drawing and forming service without costly dies

saves up to 90% on tooling... ideal for short and medium production runs!

Hydroforming is a versatile, economical form of simplified deep drawing that operates without conventional, costly dies. It combines extreme precision in deep drawing with low-cost tooling and fast parts delivery. Hydroforming saves up to 90% on tooling costs, speeds model development work, and gives your designers unequalled freedom. While showing its best advantage on medium and smaller runs, it does sometimes produce parts that are impossible to produce by any other process. An idea of the tooling costs for Hydroforming are illustrated by the parts shown.



Write, wire, or call for details, or send your prints for estimates—in strictest confidence, of course.

Hydroforming Company of America

7406 W. Lawrence Ave., Chicago 31, Illinois PHONE: UNderhill 7-7600

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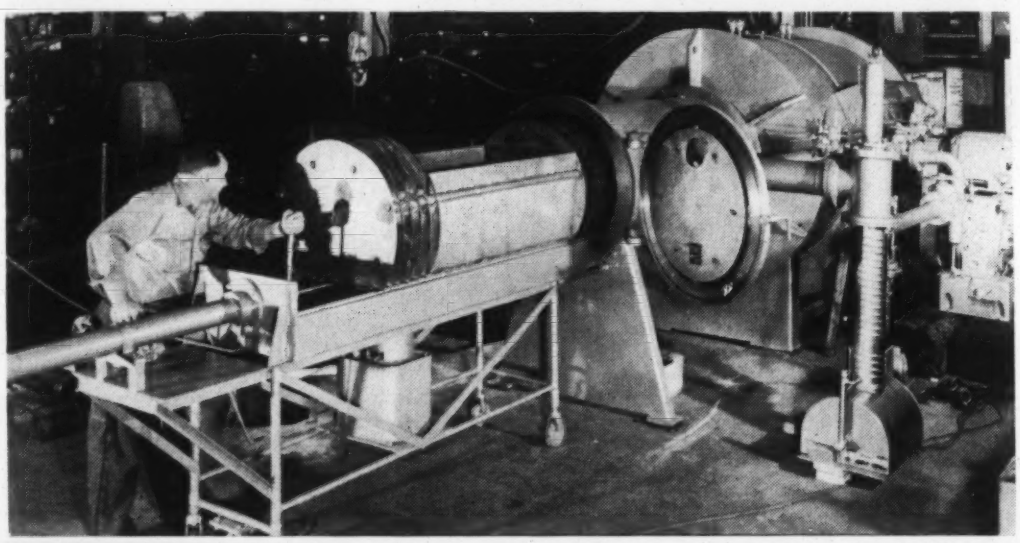
News OF INDUSTRY



Vacuum brazing—The horizontal retort vacuum furnace shown in the accompanying photo is used by Martin Co. for experimental and limited production vacuum brazing of aircraft components. The furnace, built by F. J. Stokes Corp. and incorporating a movable work-holding boat, is said to be the largest of this type ever constructed.

In operation, parts are loaded into the movable boat which is then driven into the two-zone vacuum chamber (right) by a hydraulic ram. The door is closed and pressure is reduced to about 20 microns (if necessary, vacuum can be drawn to below 1 micron). Resistance heating elements in the furnace raise the temperature to as high as 2150 F. After processing, the work boat is withdrawn into a water jacketed cooling zone for controlled cooling.

Committee on Cermets Established by ASTM

The American Society for Testing Materials has approved the formation of a study committee in the field of cermets. The committee will study and observe commercial progress in order to establish test methods and product standards.

The authorization for the committee came as a result of a conference held last November in which it was revealed that at present practically all of the materials produced as cermets are made for experimental usage, with no one type being made by more than one manufacturer. The committee will promote information on the subject in the form of papers, meetings and symposiums.

New X-Ray Device Analyzes, Magnifies

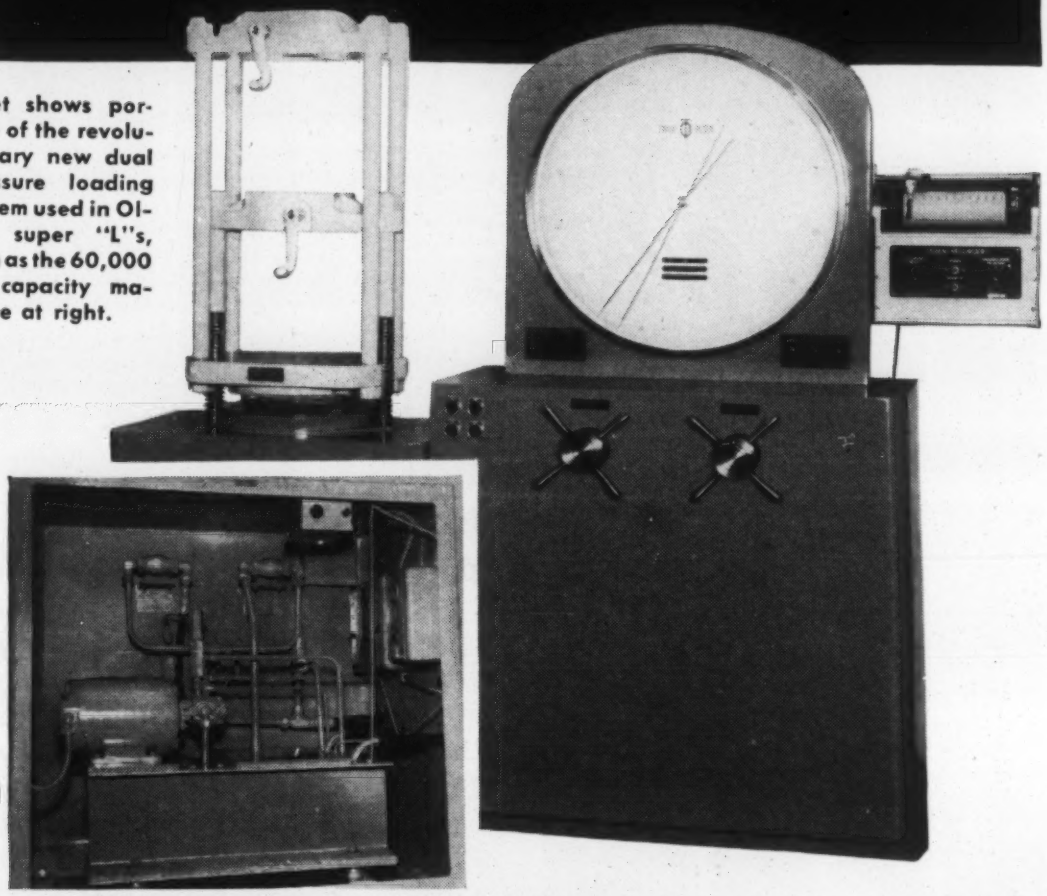
A new x-ray device that can analyze a given element in alloy steel in 10 sec, or can magnify the atomic structure of materials 150 times, has been installed in the metallurgical laboratory of Buick Motors Div., General Motors Corp.

Verne Hense, Buick chief metallurgist, says the new instrument reduces by more than 4 hr the time needed to analyze some metallic elements as compared with the conventional wet chemical method. "In addition," Mr. Hense points out, "it reveals facts about the structural make-up of materials that are nearly impossible to obtain in any other manner, giving us a new and better approach to quality control problems."

The instrument is a combination x-ray spectrometer-diffractometer and microradiography apparatus that fires a 50,000-v x-ray beam to probe inside hardened steels or even carbide cutting tools which defy analysis by any other means.

Used as a spectrometer, it can determine the exact percentage of manganese, molybdenum or any other metallic element in a steel bar or roll to insure that the composition of the steel meets quality standards. As a diffractometer the instrument magnifies atomic structures to the extent that the arrangement of atoms in a piece

NEW, SUPERIOR LOADING SYSTEM
Used Exclusively



Inset shows portion of the revolutionary new dual pressure loading system used in Olsen super "L"s, such as the 60,000 lb. capacity machine at right.

in TINIUS OLSEN Super "L" UTMs

Keeping pace with the revolutionary SelecTrange Indicating System, the hydraulic loading system used in all Tinius Olsen Super "L" testing machines has been completely modernized. Uniform load application is assured by the new, exclusive Olsen stabilized piston design. This includes a dual pressure pump which provides positive piston lubrication under all loading conditions. The oil reservoir is shock mounted and flexible connections are used so that no vibration or pulsation is transferred to the indicating system.

Loads are indicated with unmatched speed and accuracy on the large color coded SelecTrange dial. With three separate ranges to choose from, loads as low as 1/50 capacity can equal full scale range for accurate load determination—and the range can be changed during test with a flip of the SelecTrange switch. When a load cell is used, loads as low as 200 grams can represent full scale.

Stress-strain curves, are plotted automatically when the Olsen Model 51 electronic recorder is used. To assure accurate curves on specimens of all types, Olsen offers the widest selection of strain instrumentation available.

For flexibility, accuracy plus unequalled ease of operation and low cost, the Tinius Olsen Super "L" is your best universal or compression testing machine buy.

Get full details. Write today for Bulletin 47.

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TESTING MACHINE COMPANY
2010 EASTON ROAD • WILLOW GROVE, PA.
Testing and Balancing Machines

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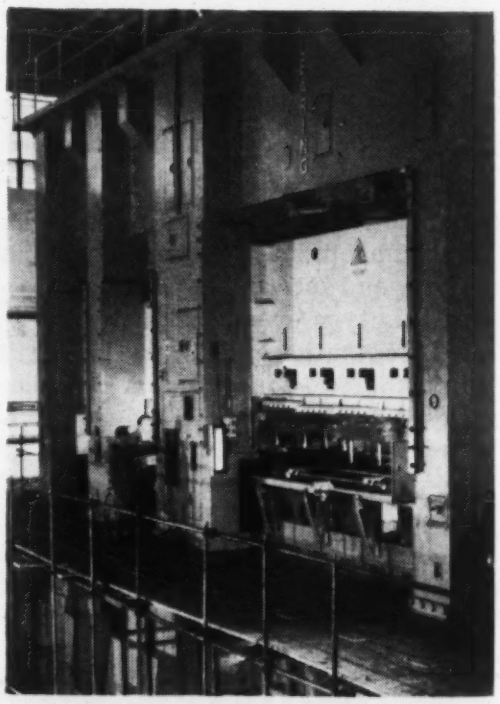
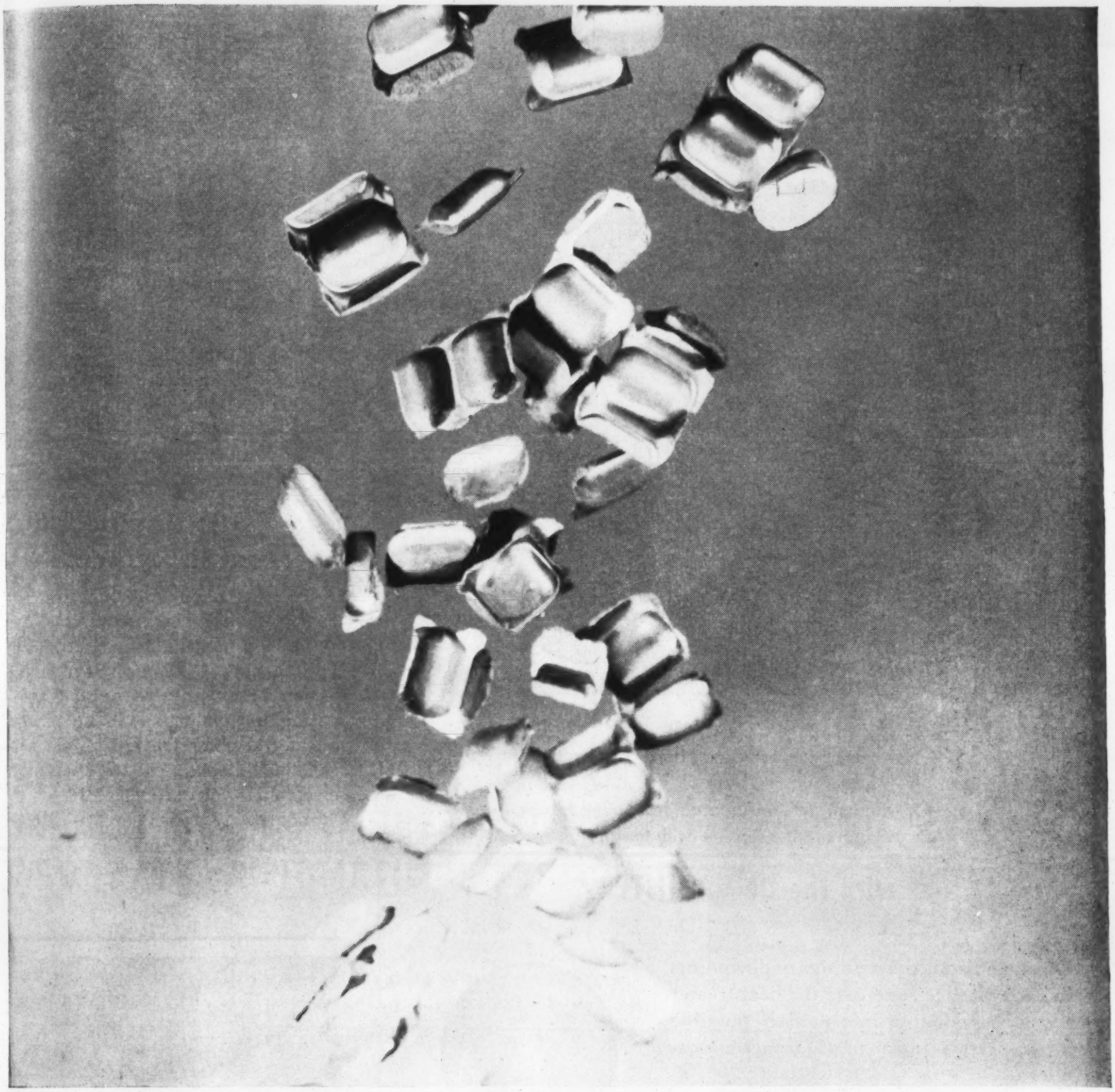
of steel can be visualized. This makes it possible to predict whether or not the part has the required wear and strength.

Magnetism Conference To Be Held This Fall

A conference on Magnetism and Magnetic Materials will be held in Washington, D. C., Nov 18-20, 1957. Sponsored by the Magnetics Subcommittee of the Basic Science Committee of the American Institute of Electrical Engineers and held in cooperation with the American Physical Society, the American Institute of Mining and



Largest transfer press—Shown here is what is claimed to be the world's largest completely automatic transfer feed press: it stands more than 42 ft high and measures over 58 ft from end to end. Built by Clearing Machine Corp. for General Electric Co., the press produces two different parts on alternate production runs without the necessity for interrupting operations in order to change dies. Changeover takes only a few minutes and is accomplished automatically. The press has a total capacity of 1600 tons and delivers 12 strokes per min.



TITANIUM BRIQUETTES...

IN PRODUCING SUPER ALLOYS and stainless steel, you'll get higher titanium residual with reduced additions of TAM titanium briquettes...plus efficient deoxidation and stabilization. The convenient uniform size and shape of the briquettes make them easy to handle. They offer higher efficiency—dissolve readily and produce a cleaner metal with low aluminum and silicon and non-metallic inclusions. Titanium powder is firmly compressed into TAM briquettes...*which do not crumble during handling.* Shipped in metal drums. For prices and delivery data, contact our New York City office.

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General Offices, Works and Research Laboratories:
Niagara Falls, New York

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detect

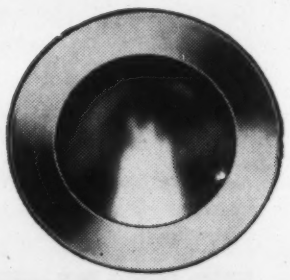
- restricted flow of atmosphere
- leaky furnace seals
- transient moisture and air from quench tank
- air carried into the furnace with the charge

with the DEWPOINTER

Quick and accurate readings of dewpoints in each furnace zone give the heat treater the most valuable information possible for accurate adjustment of furnace atmosphere.

In one relatively inexpensive unit, the Dewpointer brings you this accurate data with simple operations. Any shop man can get precise readings every time—for the maximum in effective furnace control.

Only the Alnor Dewpointer gives you controlled test conditions...indications take place in an enclosed chamber. Dew or fog is suspended in the air as sunbeams —not on a polished surface. This unique principle gives you the greater accuracy, faster readings required for critical heat treating atmosphere control.



Eliminate Guesswork
Here's what you actually see with a Dewpointer—a swirl of sunbeams that is unmistakable in reading. Find out why so many use the Dewpointer for atmosphere control. Send for your copy of the illustrated Dewpointer Bulletin. Write: Illinois Testing Laboratories, Inc., Dept. 522, 420 North LaSalle Street, Chicago 10, Ill.

Alnor

ILLINOIS TESTING LABORATORIES, INC.

For more information, turn to Reader Service card, circle No. 377

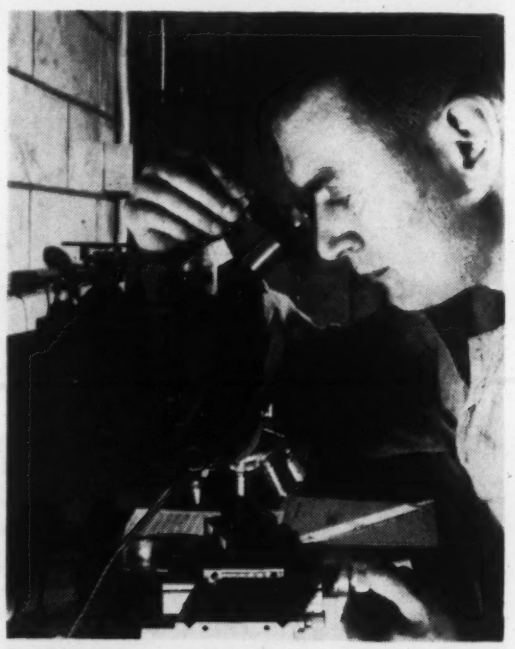
News OF INDUSTRY

Metallurgical Engineers, the Institute of Radio Engineers, and the Office of Naval Research, the conference will be concerned primarily with basic and applied work on magnetism. Representative of the many topics to be covered at the conference are: new materials; metallurgy and magnetism; structure studies; and magnetostriction.

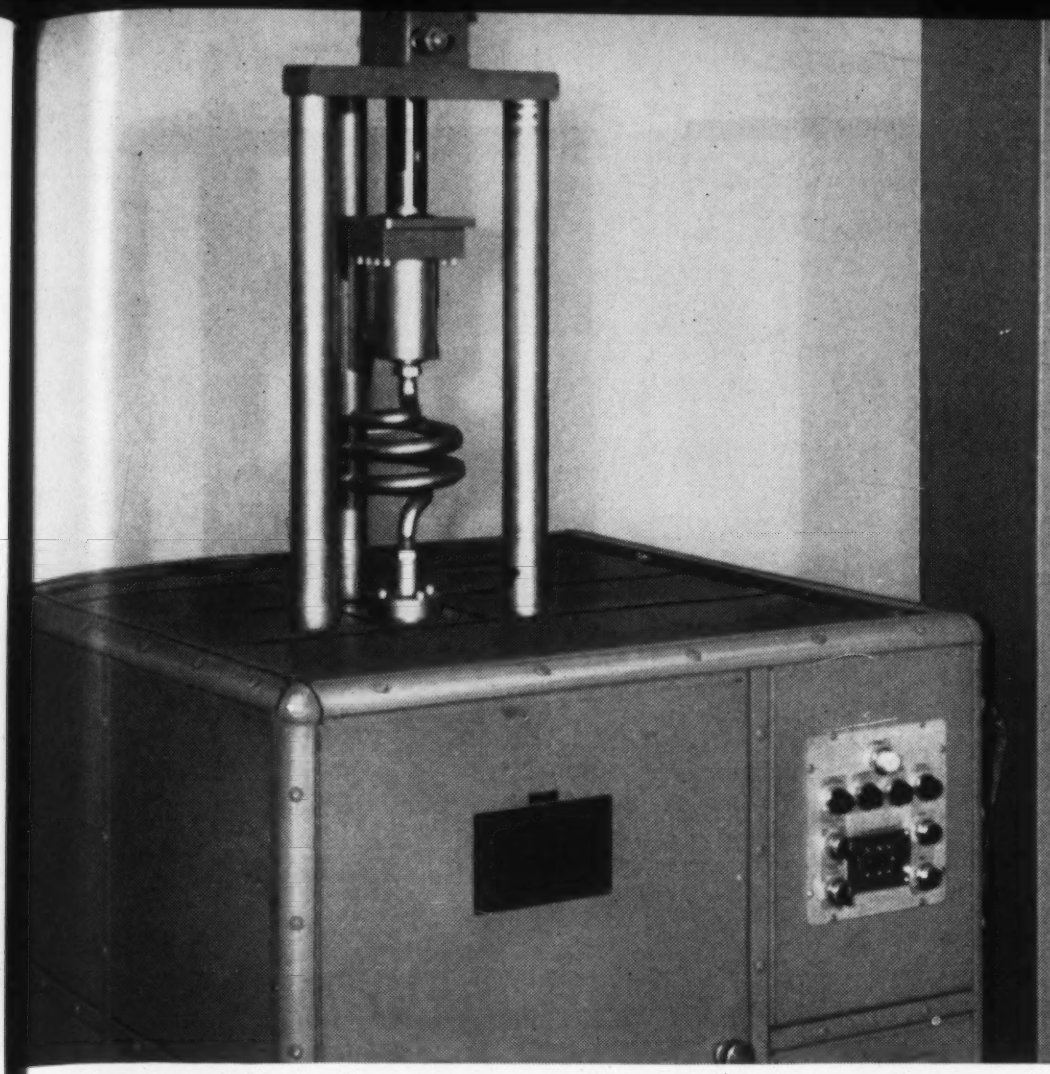
Standards Engineers To Meet in September

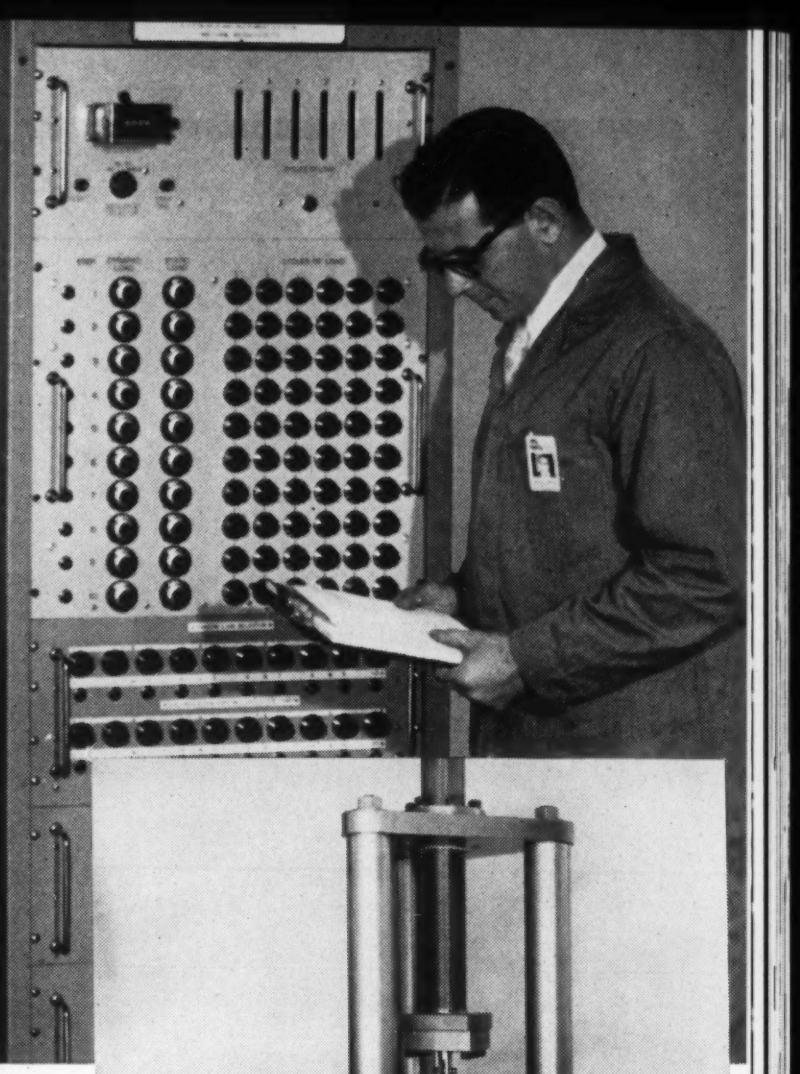
The sixth annual meeting of the Standards Engineers Society, to be held next month, Sept 23-25, will have as its theme "Standardization—Economy Through Application." Emphasis will be placed on engineering materials, electrical and mechanical components, electronic circuitry, and how standards can be used to solve purchasing problems.

(News of Engineers on p 226)



Hardness testing—One of the projects being carried out in Dravo Corp's new research laboratory is determining the microhardness of metals. Shown here is a microhardness tester used to test the hardness of a single grain of steel or the end of a steel wire 0.001 in. in dia.





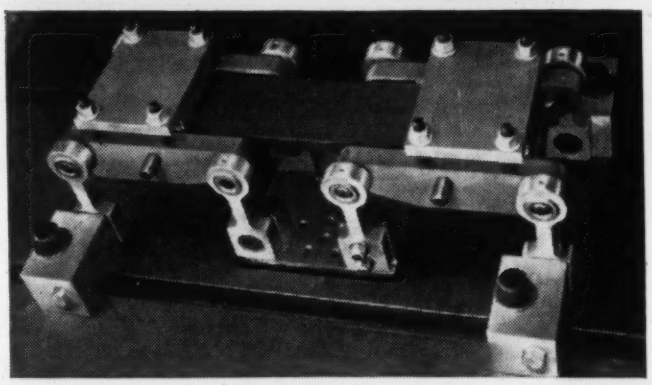
The Baldwin SF-1-U Universal Fatigue Machine shown here is being controlled by the Baldwin Programmer at its side. Entire sequences of varying static or dynamic loads can be run off, all in one automatic operation.

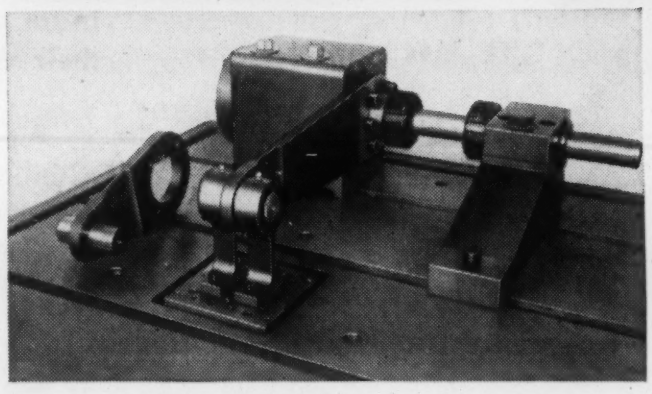
BALDWIN MAKES EVEN SEVERE, PROGRAMMED FATIGUE TESTS AN ACCURATE, AUTOMATIC OPERATION

Here is simulated service testing with flexibility, accuracy and ease never before possible! Baldwin Universal Fatigue Machines have capacities ranging from 50 lb. to 10,000 lb. With proper fixtures, almost any combination of static and dynamic stress may be obtained. Load accuracy is within ±2% of load or 0.4% of capacity, whichever is greater.

Add a Baldwin Programmer to your Baldwin SF-1-U Fatigue Machine, and you have testing automation! Complete test sequences can be set up on the programmer controls and run off on the fatigue machine without supervision. Varying static or dynamic loads, for any predetermined number of cycles are possible. Loads can be changed at approximately 500 lb. per min.

For the best in testing, see Baldwin first . . . choose from a complete line of equipment for testing compression, tension, creep, fatigue, impact or torsion. Write today and ask to have a Baldwin representative call on you.





Fixtures for Universal Fatigue Machines include (top to bottom) amplification, bending and torsion.

BALDWIN · LIMA · HAMILTON

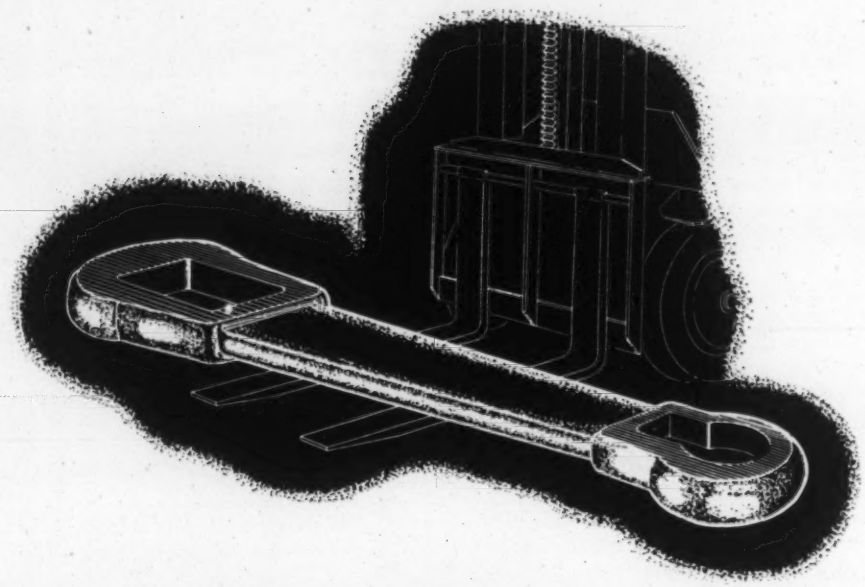
Electronics & Instrumentation Division

Waltham, Mass.

Testing machines • SR-4® strain gages • Transducers

For more information, turn to Reader Service card, circle No. 497

Worn? Mismachined?



VANDERLOY*

is the answer.

Connecting rods, power cylinders, shafts, rods—i.d. or o.d. surfaces—all can be restored to design dimensions by the application of VANDERLOY.*

VANDERLOY* **an electrolytic iron that bonds atomically with most ferrous metals, aluminum, copper, nickel and their alloys.**

Write for additional information on this NEW reclamation service.
Dept. E, VAN DER HORST CORPORATION, Olean, N. Y.

VAN DER HORST TRADE MARK

TERRELL, TEXAS
OLEAN, NEW YORK
LOS ANGELES, CALIFORNIA**
HILVERSUM, HOLLAND

*Patents applied for

**SparTan Engineering
West Coast Licensee

News OF INDUSTRY

Engineers

Wilson H. Moriarty, National Malleable & Steel Castings Co., has received the Charles H. McCrea award from the Malleable Founders' Society for unusual contribution to the industry.

Dr. Francis J. Shortsleeve has been appointed assistant director of research, Metals Research Laboratories, Electro Metallurgical Co., div. of Union Carbide Corp.

Edward Foodim is now assistant to the president, Consolidated Avionics Corp. Ira L. Kasindorf succeeds Mr. Foodim as chief engineer.

Alfred A. Rodick is chief engineer, G. Felsenthal Sons, Inc.

Dr. Thomas P. May has been raised from technical manager to station manager of the Kure Beach-Harbor Island station of International Nickel Co. Dr. May will transfer his headquarters from N. Y. to the station.

Richard L. Olson, Dike-O-Seal Inc., has received the Gold Medal Diploma, awarded by the 6th International Inventors exhibition, for the originality and application of his method of sealing foundry core boxes and cavitated assemblies.

Charles D. Preusch has been advanced to chief metallurgist, Spaulding Works, Crucible Steel Co. of America.

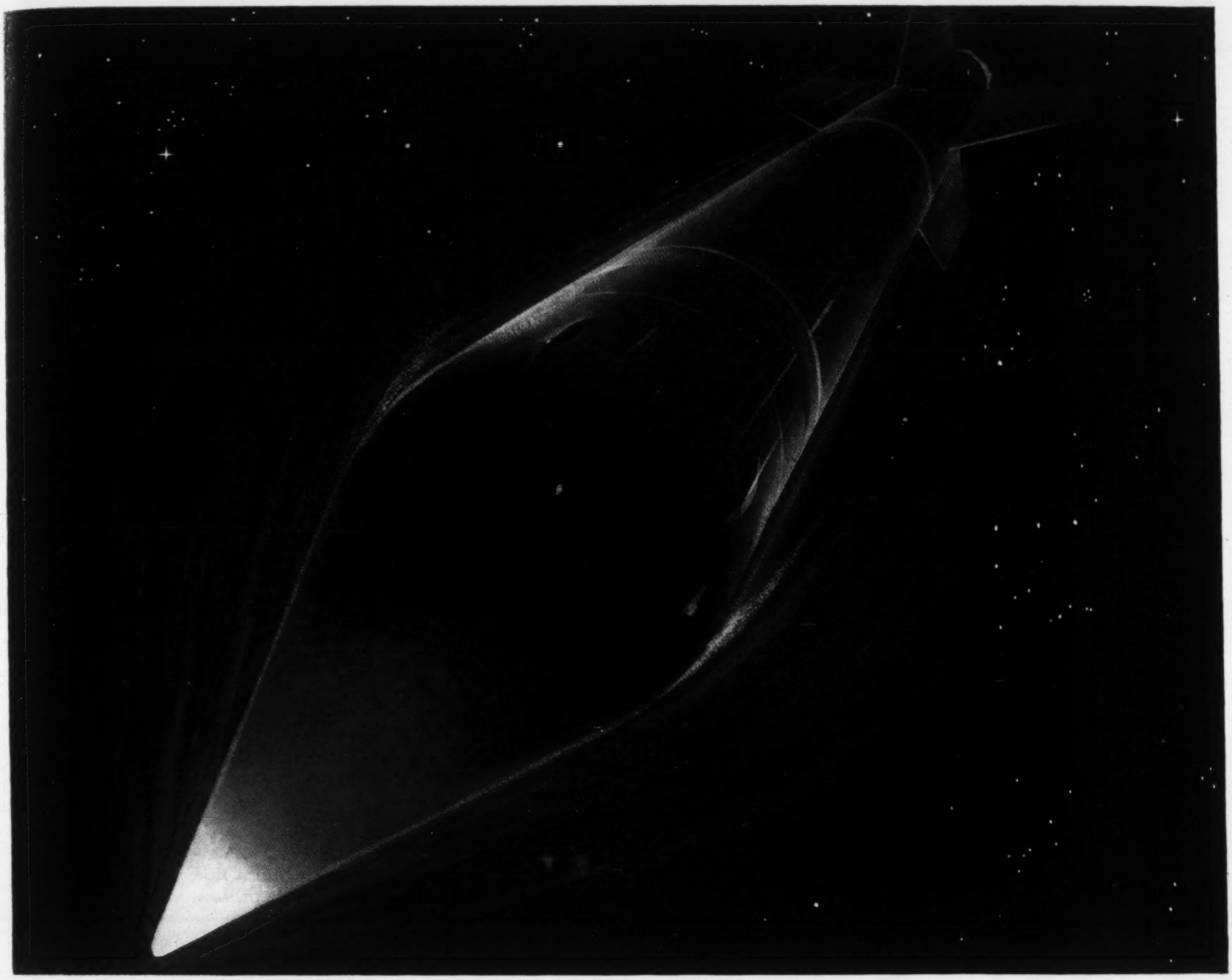
Charles Aust has been assigned to the newly created post of technical director, Goshen Rubber Co., Inc.

A. F. Mohri, chief metallurgist, Steel Co. of Canada, has received the American Iron and Steel Institute Medal for his paper, "Metallurgical Aspects in the Design and Operation of a New Continuous Annealing Line."

Dr. Morris Rubinoff has joined Philco Corp's. Government & Industrial Div. as manager of digital computer engineering.

William D. Cleeves is now assistant manager of engineering, Construction Equipment Div., Blaw-Knox Co.

Melvin Martins, electronics engineer, Colson Corp. has received a gold



Sustained operating temperatures up to 400° F, as in guided missiles, are death to inferior electrical insulations and laminates. CDF glass-base laminates of Teflon*—the only laminates of their kind approved by the military—can take this punishment steadily.

LATEST HIGH-HEAT INSULATION SYSTEMS NEED CDF GLASS-BASE LAMINATES AND TAPES

Widest available range offers Teflon, epoxy, silicone, mica products for dimensional stability under continuous heat

As components and equipment grow smaller, and heat becomes more difficult to dissipate, CDF high-heat electrical insulations become increasingly important to electronic design. For nowhere else can such a wide range of quality insulations be found under one roof as at CDF.

FOR HIGH-HEAT PRINTED CIRCUITRY, CDF glass-base metal-clad laminates of Teflon* and epoxy exhibit best dimensional stability and current-carrying capacity. Constant operating temperatures of 300°F — soldering temperatures to 500°F — are readily met by these specialized CDF Dilecto® laminates.

HIGH-HEAT FLEXIBLE INSULATIONS. CDF offers a wide choice of insulating tapes made of Teflon, silicone varnish, silicone rubber, and Micabond®, with glass-cloth support. CDF tapes may be used either by hand wrapping or on automatic winding machines. Unsupported Teflon in colors available to meet MIL-STD 104.

TEFLON SPAGHETTI TUBING AND OTHER SPECIALTIES. Part of CDF's vast fabrication facilities is devoted to the production of custom parts from Teflon — spaghetti tubing, rods, sheets, and machined parts to rigid specifications.

NEW — *cementable* Teflon, bondable to itself and to other materials with commercial adhesives.

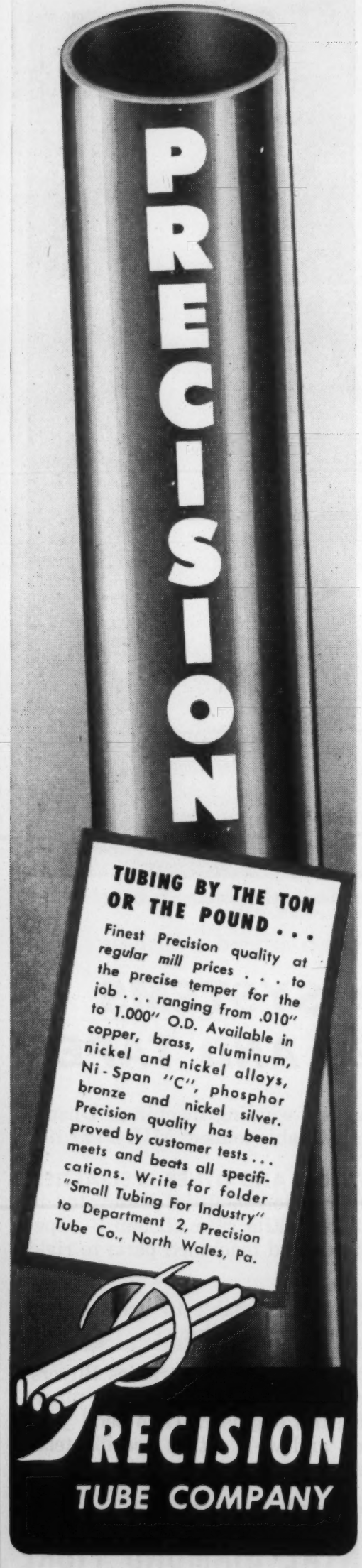
SEE SWEET'S Product Design File, Electronics Buyers' Guide, and other directories for the name and phone number of your CDF sales engineer. Then send your print or your problem, and we'll return specific technical data and test samples.

*trademark of DuPont tetrafluoroethylene resin

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 25, DEL.

For more information, turn to Reader Service card, circle No. 489


PRECISION
TUBING BY THE TON OR THE POUND . . .
Finest Precision quality at regular mill prices . . . to the precise temper for the job . . . ranging from .010" to 1.000" O.D. Available in copper, brass, aluminum, nickel and nickel alloys, Ni-Span "C", phosphor bronze and nickel silver. Precision quality has been proved by customer tests . . . meets and beats all specifications. Write for folder "Small Tubing For Industry" to Department 2, Precision Tube Co., North Wales, Pa.
PRECISION
TUBE COMPANY

News OF INDUSTRY

medal from Secretary of Commerce Weeks in recognition of his part in the development of a new instrument for the Census Bureau.

G. J. Wilson is now general manager at the new Florida plant of Milton Roy Co. **George W. Schneider** has been appointed manager of research and development, Analytical Instrument Div., and **Milton R. Sheen** manager of manufacturing. **John P. Klembeth** has joined Milton Roy Co. as assistant chief engineer.

Dr. Shadburn Marshall has joined the Central Research Laboratories of Air Reduction Co., Inc., as director of metallurgical research.

E. E. Proesch is now assistant general manager in charge of engineering, Belco Industrial Equipment Div., Bogue Electric Mfg. Co.

Noah A. Kahn, chief metallurgist, N. Y. Naval Shipyard material laboratory, died in June while attending a conference of the American Society for Testing Materials. He was 62.

Companies

Popular Fibreglass Products Corp., a subsidiary of Popular Plastic Products Corp., has moved to larger quarters in Copiague, L. I.

Marbon Chemical Div., Borg-Warner Corp., is operating a new $10 million chemical plant near Parkersburg, W. Va. This is the corporation's first large-scale investment in the plastics field.

National Automatic Tool Co., Inc., announces formation of a Plastics Machinery Div. for the production of plastics injection molding machines. The new division will occupy a recently completed plant addition.

L. L. Constantin & Co. has acquired a 20,000-sq-ft building in Saddle Brook, N. J., to permit expansion of design facilities and a 40% increase in production.

Denison Research Foundation, Powell, Ohio, has organized as a not-for-profit corporation to provide research

NEW

Luster-on®

52 POWDER

PROTECTS and BRIGHTENS ZINC at LOWEST COST YET

LUSTER-ON 52 POWDER *is a low, low priced single dip, no-leach conversion coating for zinc plated surfaces.*

LUSTER-ON 52 POWDER was recently developed by The Chemical Corporation for automatic equipment where facilities are not available for added leaching and rinsing.

LUSTER-ON 52 POWDER gives a bright bluish hue; provides lasting corrosion protection against staining, tarnishing and white powder products.

LUSTER-ON 52 POWDER can *now* be used in cases where cost has prohibited use of chromates in the past. For instance, electrical conduit, conduit boxes, screws and builder's hardware, tools, electronic parts, air conditioning parts, automotive parts, cheap toys.

LUSTER-ON 52 POWDER is not only low, low in price, but eliminates expensive handling, space-consuming storage and carboy deposits.

Still available, of course — time-tested Luster-On liquid dips and coatings for all your needs.

Data Sheets and Prices on Request.
Send in part for free processing.

West Coast: Crown Chem. & Engr.
Los Angeles & San Francisco
Canadian Licensee: Alloycraft Ltd.
Montreal

THE *Chemical* CORPORATION

67 Waltham Ave. • Springfield 9, Mass.

For more information, circle No. 541

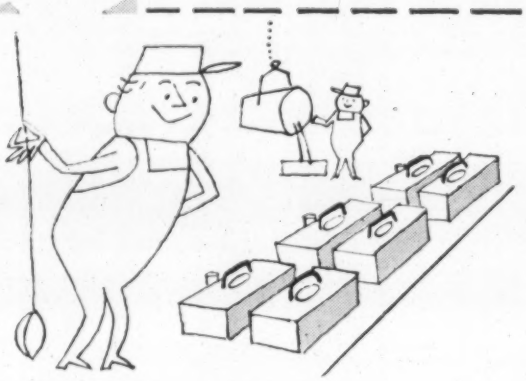
For more information, circle No. 460

Q

Saving all you can on

Production Bronze Castings?

Here?



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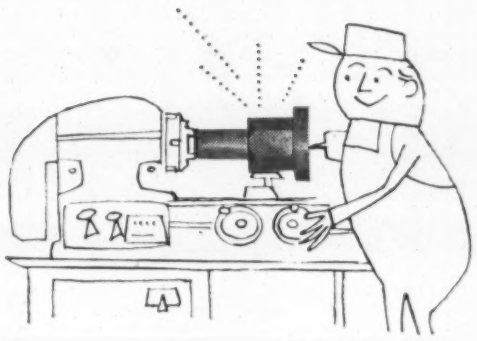


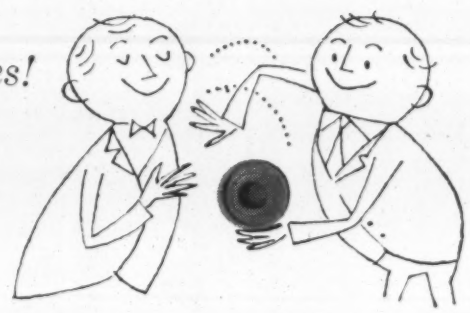
A

You do, with

Ampco Shell Moldings!

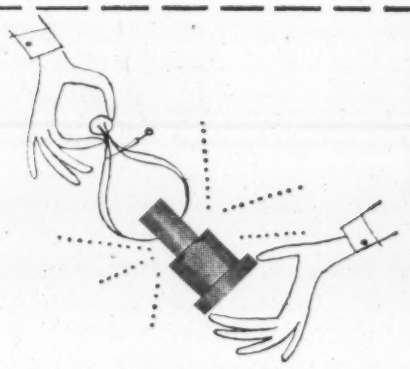
Smoother cast surfaces!

Often, smooth enough to use as is.



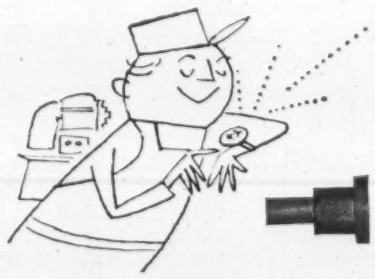
Closer tolerances!

Most castings held to ±.015 — favorable shapes, ±.010.



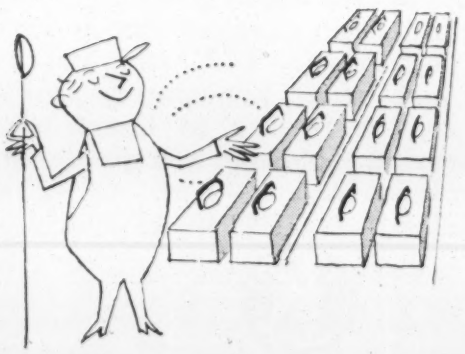
Less machining!

In some cases, finishing operations are eliminated.



Lower cost!

High-speed, semi-automatic mold production means foundry economy.



AMPCO®

THE METAL WITHOUT AN EQUAL

AMPCO METAL, INC.
Milwaukee 46, Wisconsin

West Coast Plant:
Burbank, California

One-source service from raw material to finished product

FREE BULLETIN TELLS MORE. TEAR OUT COUPON AND MAIL TODAY!

AMPCO METAL, INC.
Dept. MI-8, Milwaukee 46, Wisconsin

Send me Bulletin G-36 on shell moldings; also information on other Ampco products I have checked.

Name.....

Title.....

Company.....

Address.....

City..... Zone..... State.....

- ☐ Specifications of Ampco Metal
- ☐ Ampco Wrought Products
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- ☐ Ampco Centrifugal Pumps
- ☐ Ampco-Weld Resistance Welding Electrodes

D-61

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SWEET K & J MUSIC

has charmed

many a tough customer

We've been working with plastics for thirty years—and those of our customers who came in with a lion's roar have settled down to a steady purr of satisfaction with K & J service.

They like our integrated engineering, mold making and molding service; our keeping delivery promises to meet their tight production schedules; our engineering help which often results in design changes that mean better performance and lower cost.

Let's get better acquainted. Our brochure, "A Service to Users of Compression Molding" will give you the whole story.

KUHN & JACOB MOLDING & TOOL CO.

1203 Southard St., Trenton 8, N.J.

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Carson Road, Princeton, N. J.
Phone 1-3170-J2

Wm. T. Wyler
Box 126, Stratford, Conn.
Phone Bridgeport 7-4293

For more information, circle No. 419

News OF INDUSTRY

talent and facilities to industry and Government. Initial emphasis will be in the electronic, mechanical, metallurgical, ceramic and management fields.

Associated Spring Corp. will establish two new precision mechanical spring manufacturing plants: one in Canada, with manufacturing operations scheduled to begin late this fall; and one in Puerto Rico, planned for operation around the end of the year.

American Laboratories Div., American Electronics, Inc., will complete its Fullerton, Calif. environmental test laboratory this month.

Air Reduction Co., Inc., is now operating its new $7,500,000 Chicago air separation facility.

Dayton Rubber Co. and **Cadillac Plastic and Chemical Co.** have merged through an exchange of stock. Cadillac Plastic will operate as a Dayton subsidiary retaining its corporate name, present management and personnel.

Norton Co. has started construction of a $6,500,000 plant for production of organic-bonded grinding wheels.

Structural Fibers, Inc., has moved to Chardon, Ohio.

Jones & Laughlin Steel Corp. has started production at its new cold finished bar mill at Willimantic, Conn.

Precision Castparts Corp. is operating a new $125,000 investment casting and shell molding plant.

Koppers Co., Inc., is moving its Philadelphia shaft seal manufacturing facilities to a newly acquired building.

Loral Electronics Corp. has moved to its new Bronx, N. Y., plant.

Societies

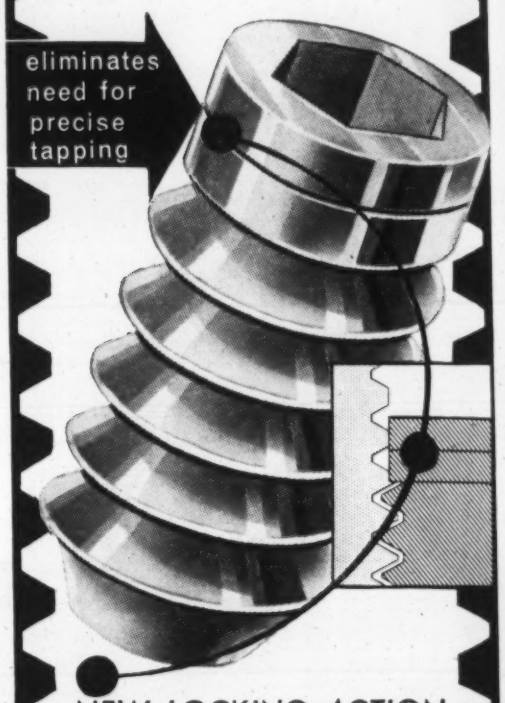
Mellon Institute is establishing a "Fundamental Research Trust" and a Trust Estate that will function in cooperation with the Institute's fundamental research programs. Fun-

For more information, circle No. 549

NEW

crest-lok self locking set screw

ideal for plastic and soft steel

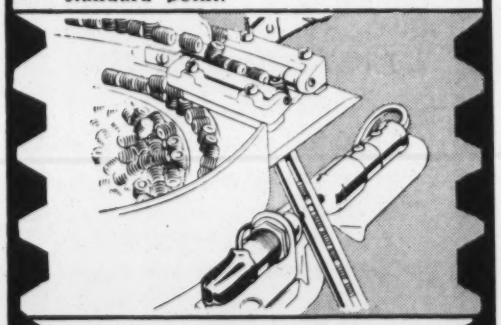


NEW LOCKING ACTION

The locking action of the CREST-LOK consists of an unthreaded portion, a thread and a half high, at the crest of the Set Screw. The diameter at the crest is approximately the blank diameter. When the screw is inserted it compresses the crest of the threads in the tapped hole, locking the screw firmly into position . . . Precisely tapped holes are not necessary.

You can control the amount of locking action of the Crest-Lok by simply changing the tap drill diameter . . . Re-use does not appreciably affect the locking action.

Crest-Lok is available in any size headless Set Screw, also with hexagon, fluted, slabbed or slotted sockets, or with Nu-Cup® or any standard point.



Crest-Lok can be Hopper-Fed with the Setko originated feeding system that brought *Automation* to Set Screw insertion. Experience has shown that insertion rates can be greatly increased.

WRITE TODAY for full information . . . and ask for Catalog 21 which describes the complete line of Setko Set Screws.

Set Screw & Mfg. Co.

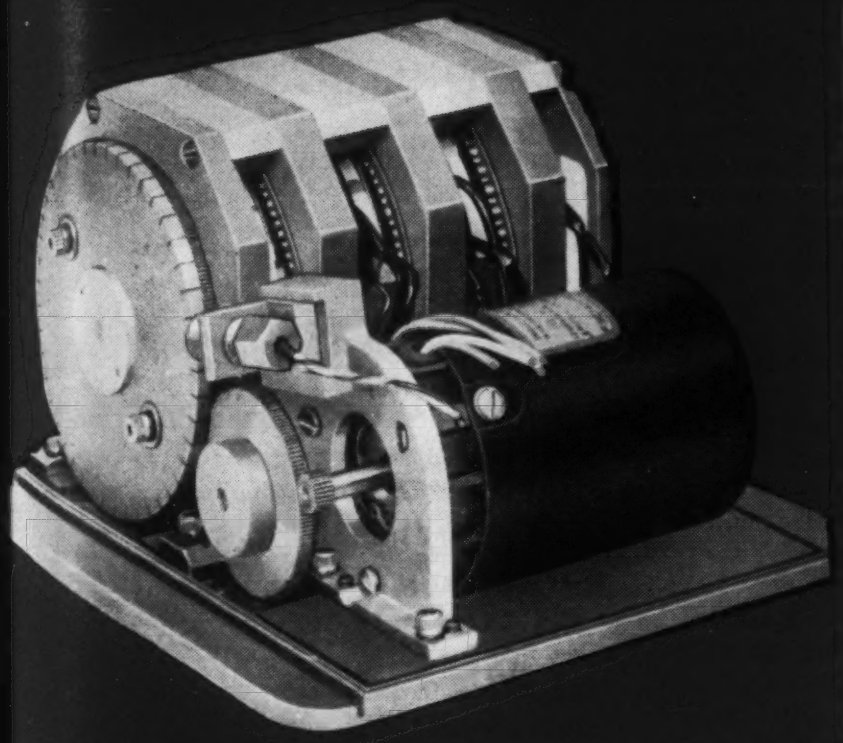
*Pat. No. 2,638,945
Other Patents Pending

149 Main Street, Bartlett, Illinois

159

For more information, circle No. 487

ESIGN ACHIEVEMENTS WITH **SUPRAMICA*** ceramoplastic



MYCALEX TM Commutation Switch for Telemetering, Using Precision-molded SUPRAMICA* 555 ceramoplastic Commutator Plates.
MYCALEX ELECTRONICS CORPORATION
Under Exclusive License of MYCALEX CORPORATION OF AMERICA

Precision-molded SUPRAMICA* 555 ceramoplastic Commutation Plate, CP-340, with 340 Contacts and 2 Slip Rings. Other Standard Plates are Available.

SUPRAMICA* ceramoplastics

PROVIDE NEW STANDARDS OF RELIABILITY FOR DESIGNERS

HIGHER TEMPERATURES . . . RADIATION RESISTANCE . . . TOTAL, PERMANENT DIMENSIONAL STABILITY . . .

SUPRAMICA ceramoplastics are precision-molded insulations with temperature endurance greater than any comparable material. Molded parts, such as the commutator plate illustrated above, have complete, permanent dimensional and electrical stability under extreme conditions of humidity and temperature.

Metal inserts molded in SUPRAMICA ceramoplastics cannot loosen during thermal cycling because coefficients of expansion are closely matched. There is no possibility of shrinkage, growth, or age polymerization, as the materials are completely inorganic, made with Synthamica* synthetic mica. Other desirable properties are high dielectric strength, radiation and arc resistance, low electrical loss, imperviousness to moisture, oil and organic solvents.

In thousands of military and industrial applications, SUPRAMICA ceramoplastics are contributing to better, safer, more reliable operation of electrical and electronic equipment

SUPRAMICA* 560 — for temperatures over 500°C. (932°F.)
SUPRAMICA* 555 — for temperatures up to 650°F.
SUPRAMICA* 500 — sheet and rod material for machining.

Write for complete information.

***SUPRAMICA is a registered trade-mark of Mycalex Corporation of America**
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SYNTHAMICA is a trade-mark of Synthetic Mica Corporation, a subsidiary of Mycalex Corporation of America

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WORLD'S LARGEST MANUFACTURER OF GLASS-BONDED MICA AND CERAMOPLASTIC PRODUCTS

Another product
made better with

MOLDED FIBER GLASS

IT'S A SWITCHBOARD COVER

non-corrosive

dielectric

strong . . . lightweight

suitable for use indoors or out

economical!

In nearly every industry there is a product which can be made *better* with MOLDED FIBER GLASS — with faster, less expensive tooling. Consultation with MOLDED FIBER GLASS engineers entails no cost or obligation. Write for information.

molded Fiber Glass company

THE GREATEST NAME IN "MOLDED FIBER GLASS" REINFORCED PLASTICS

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Ashtabula, Ohio

For more information, circle No. 499

News OF INDUSTRY

damental research is presently planned to cover physical chemistry; chemical physics; inorganic, organic and analytical chemistry; solid state investigations; polymer chemistry and physics; radiation studies; and biophysics and biophysical chemistry. Results of research will be freely available to the public.

American Institute of Industrial Engineers has inaugurated Dean Gordon B. Carson, Ohio State College of Engineering, as president.

American Society for Testing Materials has elected the following officers: president—Richard T. Kropf, Belding Heminway Co., Inc.; vice-president—F. L. LaQue, International Nickel Co., Inc. Directors elected are: C. L. Clark, Timken Roller Bearing Co.; A. E. June, B. F. Goodrich Co.; J. H. Koenig, Rutgers University; R. E Peterson, Westinghouse Electric Corp.; and R. W. Seniff, Baltimore & Ohio Railroad Co.

At its recent annual meeting the following twelve men were presented with Awards of Merit for outstanding service to the Society: John Ward Bolton, retired director of metallurgical research and testing, Lunkenheimer Co.; Donald Lewis Colwell, Apex Smelting Co.; Albert George Henry Dietz, Massachusetts Institute of Technology; Theodore Parker Dresser, Jr., Abbot A. Hanks, Inc.; Edgar W. Fasig, Lowe Brothers Co.; Paul V. Faragher, retired, Aluminum Co. of America; William Arthur Kennedy, deceased, Grinnell Co., Inc.; Wilmer H. Koch, Olin Mathieson Chemical Corp.; R. E. Penrod, retired, Bethlehem Steel Co.; Frank Walter Reinhart, National Bureau of Standards; Francis G. Tatnall, Tatnall Measuring Systems Co.; and Walter Charles Voss, Massachusetts Institute of Technology.

National Association of Plastic Fabricators re-elected its entire board of directors during its first annual meeting.

Magnesium Assn. elected the following officers: president—Philip B. Craighead, Magnesium Products of Milwaukee; vice-presidents—Otis E. Grant, Magnode Products, Inc., and John Thomson, Dominion Magnesium,

Cold Heading Cost Savings

Actual Cost Cuts As High As 70%

The most important consideration we can point out to the designer or purchaser of fasteners and small parts is that any part which can be machined from rod stock is also potentially available from the cold heading manufacturer. This technique offers speed of production, without scrap loss, plus superior strength and appearance for low cost and high design efficiency.

The designer need not be restricted to standard fastener sizes when they do not meet the requirements of his application. It is often much less expensive to specify a rivet, nail or screw to meet the task exactly as the application requires, than it is to compromise its function for the sake of "standards." While there is nothing mysterious about the cold heading process, experience has proved it to be of inestimable value for getting maximum quality and output at a minimum cost. While the really spectacular advantages in cost show up in runs of several thousand pieces, we are also able to take care of short run requirements. We welcome and expect manufacturers to come to us for advice and assistance concerning their fastener problems.

Given complete specifications, including a drawing and an idea of the application, we can quickly tell you whether or not it will be advantageous to have your fastener or part JOB-DESIGNED by HASSALL. The remaining important aspect of our service to you is the ability to get into production quickly and make prompt shipment.

Write for a copy of our new booklet, "What the Designer Should Know about Cold Heading".

John Hassall, Inc.

P. O. Box 2174

Westbury, Long Island, N. Y.

For more information, circle No. 425

Someday the coat worn by this mink will sell for perhaps $70. Her pelt, known as cerulean mink, along with some 65 others, may go into a full-length coat tagged as high as $10,000.

Bethanized wire guards her $70 mink coat

When stylish, light-colored mink fur shows the slightest trace of rust stain, its value may be cut in half. This downgrading of the pelts—and the constant replacing of the rusted wire pens—adds up to a big loss for the mink ranchers.

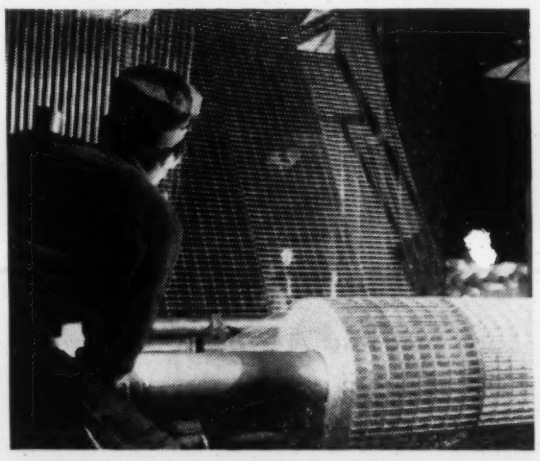
Mink pens made from ordinary galvanized steel wire just won't hold up under the abrasive wear of the animal's feet and the harsh corrosion caused by their body acid. Some years ago a manufacturer of welded wire fabric, was asked by a nearby rancher to see if an answer could be found.

It was decided that bethanized wire with an extra heavy coating of pure zinc would do the job if anything could. Some experimental pens were placed in service using the bethanized "C" coating. And after several years of normal use, it was obvious that the answer had been found. There was not one rust spot on the bethanized wire. And subsequent results have verified this test. As a result, more and more fur ranchers are enthusiastic users of fabric made from bethanized wire.

* * *

Bethanized wire has a smooth, uniform coating of pure zinc which is deposited electrolytically. In our unique process the zinc goes on atom by atom. There are no thin spots for corrosion to attack. Because of its 99.9-pct purity, the tightly bonded zinc is highly ductile and withstands severe forming.

We can supply bethanized wire in hard or soft temper, with light, medium, or heavy zinc coatings. We'll be glad to send you Folder 615 which gives more details. Write Publications Dept., Room 1037, Bethlehem Steel Co., Bethlehem, Pa.



Bethanized wire sparkles as welded-fabric is spooled in 100-ft rolls. This fabric assures long protection against corrosion because the uniform coating of pure zinc is tightly bonded to the steel.

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BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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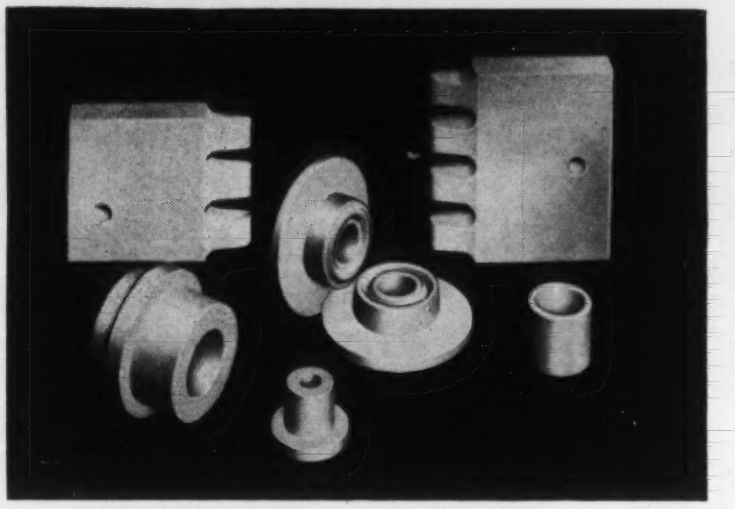
For more information, turn to Reader Service card, circle No. 403



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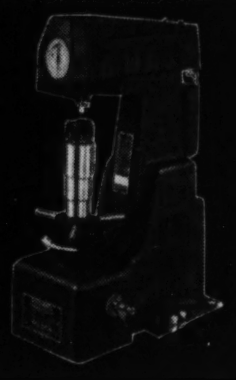

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News of Industry

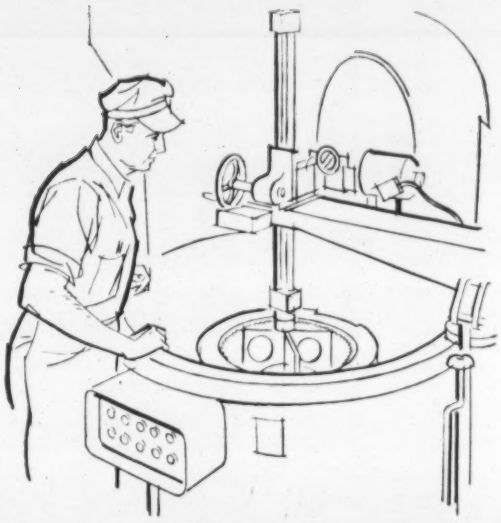
Ltd.; treasurer—James V. Cosman. Directors elected are: S. E. Bohn, Howard Foundry Co.; W. C. Britton, Sequoia Metalcraft Co.; Wiser Brown, Aluminum Co. of America; E. S. Christiansen, Magnesium Co. of America; Anthony Cristello, American Light Alloys; Dr. Fred J. Dunkerley, Rolle Mfg. Corp.; R. D. Ferguson, Bendix Foundries; J. D. Hanawalt, Dow Chemical Co.; J. B. Heisler, A. C. Williams Co.; C. A. Howe, Hills-McCanna Co.; C. E. Larson, White Metal R & S Corp.; W. H. Osborne, Acme Aluminum Foundry Co.; J. E. Pepall, Magnesium Co. of Canada, Ltd.; E. H. Perkins, Brooks & Perkins, Inc.; R. D. Taylor, Federated Metals Div., American Smelting & Refining Co.

American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., has reorganized its three branches as societies within AIME. The groups are: the Metallurgical Society of AIME, the Society of Mining Engineers of AIME and the Society of Petroleum Engineers of AIME.

Society of the Plastics Industry, Inc., has elected the following officers: president and director—C. Russell Mahaney, St. Regis Paper Co.; chairman of the board—Norman Anderson, General Molded Products, Inc.; vice president and director—R. B. Gutsch, aaRBee Plastic Co.

The board of directors was enlarged to include directors for two additional divisions, and one additional director at large. The new directors are: Cellular Plastics Div.—Paul G. Roach, United States Rubber Co.; director at large—Larry Gering, Gering Products, Inc. Other newly elected directors are: New England Section, C. W. Bentley, Colt's Plastic Co., Inc.; Pacific Coast Section—Elmer N. Huling, Wilcox Plastics, Inc.; Wall Tile Div.—E. M. Osgood, American-Standard; Canadian Section—Robert T. Todd, Minnesota Mining & Mfg. of Canada, Ltd.; director at large—Robert K. Mueller, Monsanto Chemical Co.; director at large—Carl H. Pottenger, Koppers Co., Inc.; director at large—R. C. Weigel, E. I. du Pont de Nemours & Co., Inc. Eleven incumbent directors were re-elected

(News of Meetings on p 236)



IH Saves $82,507 Per Year

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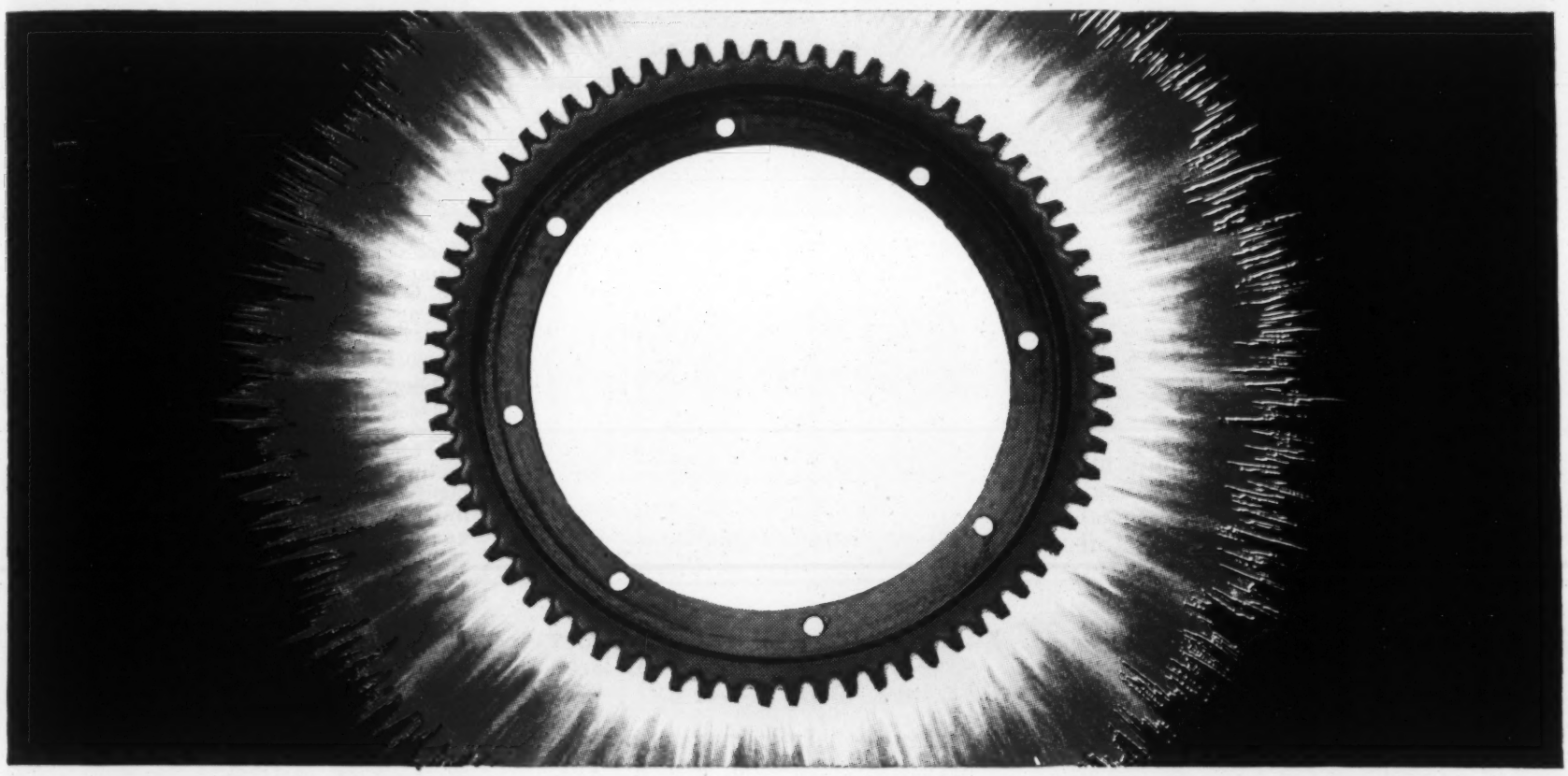

Gears, shafts, pins, wheels, tubes and bars—almost any size or shape of part—or any metal, too—is adaptable to TOCCO hardening, brazing, annealing or heating for forging.

Production Up—Engineers at the Milwaukee Works of International Harvester Company have adopted TOCCO for hardening final drive gears for famous International Harvester farm tractors. TOCCO increases production on the gear shown here from 14 to 35 per hour, 250% faster than conventional heating method, reduces job from a 3 shift to 2 shift operation, even with increased production schedule. Heating time is 35 seconds; oil quench, 60 seconds.

Costs Down—TOCCO cuts cost—saves $82,507 per year on application shown above. TOCCO makes possible use of C-1050 A.R.R. steel instead of expensive A-8645-H alloy steel previously required. TOCCO also eliminates shot-blast, formerly needed to remove scale, and extra machining operations that used to be necessary to compensate for distortion.

Gear shown is 18½" O.D., width of face is 2", weight 34 pounds, 73 teeth. Hardness obtained is 55-66 R.C., using 140 K.W. of 10,000 cycle power.

Our Engineers can probably find applications in your plant where TOCCO can increase output and reduce unit costs.

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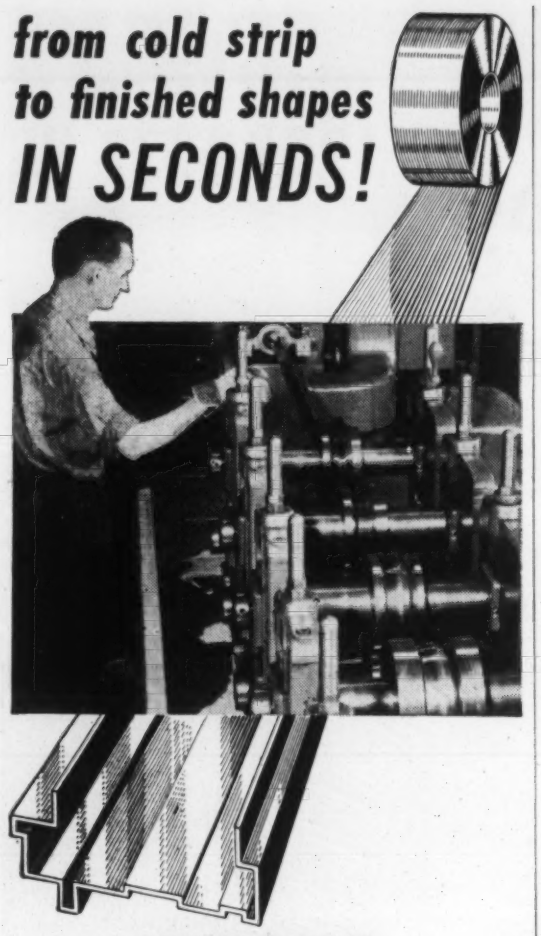

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A new, revised, Fifth Edition of the Yoder Cold-Roll Forming book is just off the press. In addition to economic and mechanical possibilities of cold-roll forming, it contains numerous illustrations of end uses and applications of roll-formed shapes. Write for your copy today.

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News OF INDUSTRY

Meetings

WESTERN ELECTRONIC SHOW AND CONVENTION, San Francisco. Aug 20-23.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor meeting and production forum. Milwaukee. Sept 9-12.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, Institute of Metals Div. Chicago. Sept 16-18.

AMERICAN DIE CASTING INSTITUTE, annual meeting. Chicago. Sept 17-20.

METAL POWDER ASSN., fall meeting. Pocono, Pa. Sept 20-21.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. Hot Springs, Va. Sept 23-24.

STANDARDS ENGINEERS SOCIETY, sixth annual meeting. New York. Sept 23-25.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Hartford. Sept 23-25.

SIXTH ANNUAL INDUSTRIAL ELECTRONICS SYMPOSIUM. Chicago. Sept 24-25.

NATIONAL SCREW MACHINE PRODUCTS ASSN., fall meeting. Colorado Springs. Sept 29-Oct 3.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aircraft engineering display. Los Angeles. Oct 1-5.

ELECTROCHEMICAL SOCIETY, INC., fall meeting. Buffalo, N. Y. Oct 6-10.

NATIONAL ELECTRONICS CONFERENCE, 13th annual conference. Chicago. Oct 7-9.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Chicago. Oct 7-11.

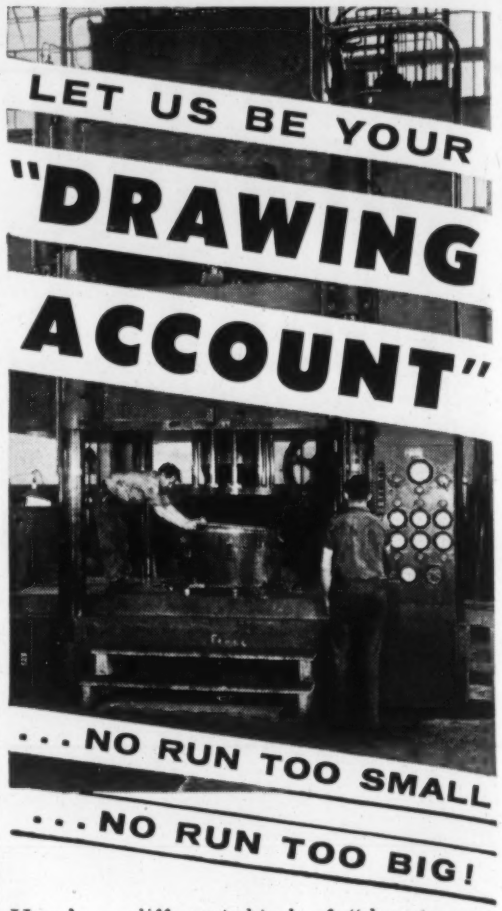
GRAY IRON FOUNDERS' SOCIETY, annual meeting. Chicago. Oct 9-11.

SOCIETY of the PLASTICS INDUSTRY, INC., 13th annual New England Section conference. Portsmouth, N.H. Oct 10-11.

PRESSED METAL INSTITUTE, annual meeting. Castle Harbor, Bermuda. Oct 13-17.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Cellular Plastics Div. Conference. New York City. Oct. 16.

MAGNESIUM ASSN., annual convention. New York City. Oct 17-18.



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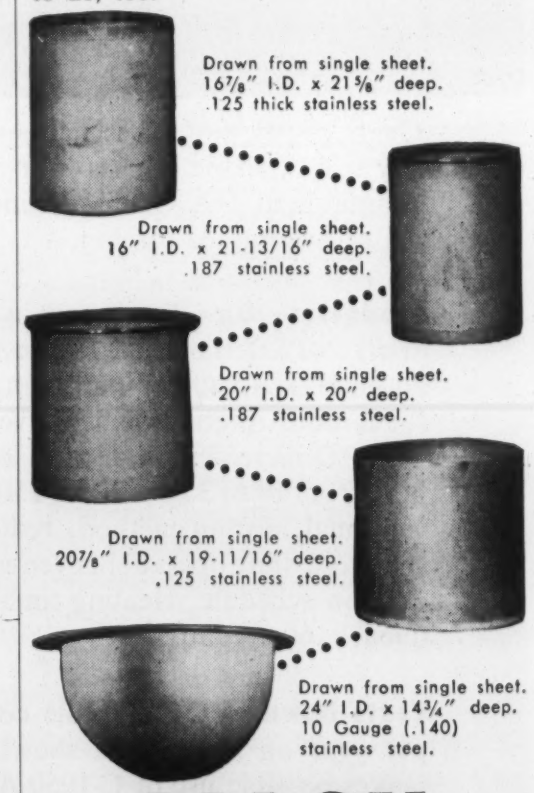

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BOOKS & REPORTS

Books

The Procedure Handbook of Arc Welding Design and Practice. *Lincoln Electric Co., Cleveland, 1957. Cloth, 6 by 9 in., 1300 pp. Price $3.00.*

Completely revised, this book covers all phases of arc welding. The book gives a history of arc welding and discusses processes, equipment, nomenclature, techniques, speeds and costs for welding steel. It contains welding information on all commonly welded metals, including such new materials as titanium and zirconium. The book also contains reference data on AISI standard steel compositions, wire and sheet gage tables, temperature conversion tables, and physical and mechanical properties of AISI steels.

Rubber: Fundamentals of Its Science and Technology. *Dr. Jean Le Bras. Chemical Publishing Co., Inc., New York, 1957. Cloth, 6 by 9 in., 464 pp. Price $12.*

Written in a simple and direct style, this book discusses the physical and chemical properties of natural, synthetic, hard and reclaimed rubbers; the chemical composition and structure of rubber and rubber latex; and tests for latex and rubber. Complicated theoretical considerations are avoided; for instance, such a complex phenomenon as the reinforcement of rubber is explained in a very simplified manner. The book contains a bibliography of books devoted to rubber, a list of rubber periodicals, and an index. Dr. Le Bras is associated with the French Rubber Institute and the Institute of Rubber Research in Indo-China.

Symposium on Minimum Property Values of Electrical Insulating Materials. *American Society for Testing Materials, Philadelphia, 1957. ASTM Special Technical Publication 188. Paper, 6 by 9 in., 48 pp. Price $1.75.*

The papers given in this symposium help solve some of the difficult problems associated with electrical insulation. Subjects include: significance of minimum property values of electrical insulating materials; variabil-

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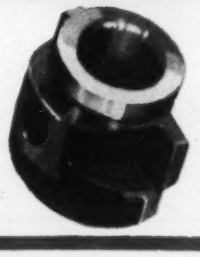

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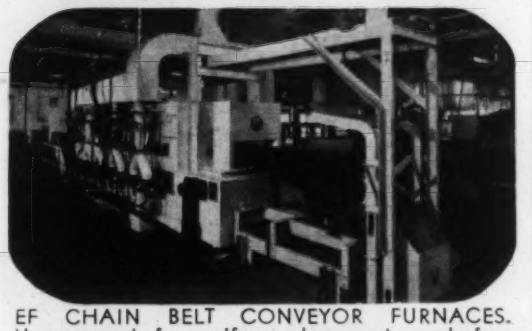

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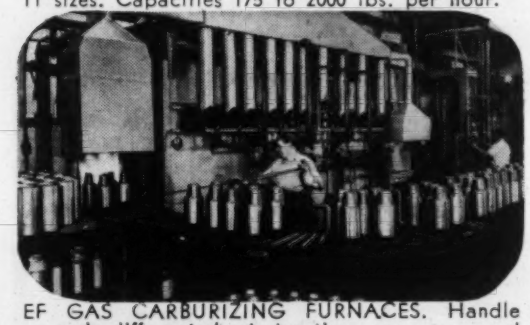

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BOOKS & REPORTS

ity of dielectric breakdown in sheet insulation; and low temperature resistance test methods for nonrigid insulation.

Metal Industry Handbook and Directory: 1957. *Iliffe & Sons Ltd., London, 1957. Paper, 6 by 9 in., 536 pp. Price $2.10.*

This book gives up-to-date information on the properties of the newer as well as the more familiar ferrous and nonferrous metals. The book is divided into four sections, the first section containing general properties of metals and alloys. The second section gives weights and measures, conversion factors, price tables, hardness tables and conversion factors for various metals. The third section contains information on electroplating, degreasing and cleaning, phosphating, and finishing aluminum and its alloys. The fourth section contains a directory of trade names, a buyers' directory, a list of metal trade associations, and a list of scientific and technical institutions.

OFHC Brand Copper. *American Metal Co., Ltd., New York, 1957. Cloth, 10½ by 7 in., 135 pp. No charge.*

Prepared by Henry M. Schleicher, one of the leading authorities on OFHC copper, this book summarizes information from a survey of world literature and unpublished research. Included are chapters covering the production, fabrication and application of OFHC; physical properties in the solid and liquid state; mechanical properties of cast and wrought material; the effects of impurities and alloying elements; and methods of testing and analysis. Properties of OFHC are given in 67 graphs and 41 tables. The book contains a bibliography of 180 references.

Boron, Calcium, Columbium, and Zirconium in Iron and Steel. *R. A. Grange, F. J. Shortsleeve, D. C. Hilty, W. O. Binder, G. T. Motock and C. M. Offenhauer. John Wiley & Sons, Inc., New York, 1957. Cloth, 6 by 9¼ in., 548 pp. Price $14.*

This is the fourth book in a series of monographs on alloying metals for iron and steel. The present volume is a collection of four separate short monographs on the use of boron, calcium, columbium (plus tantalum) and zirconium as alloying metals with iron and steel. Each monograph, written by one or more authorities in the field, contains a historical review, heat treating

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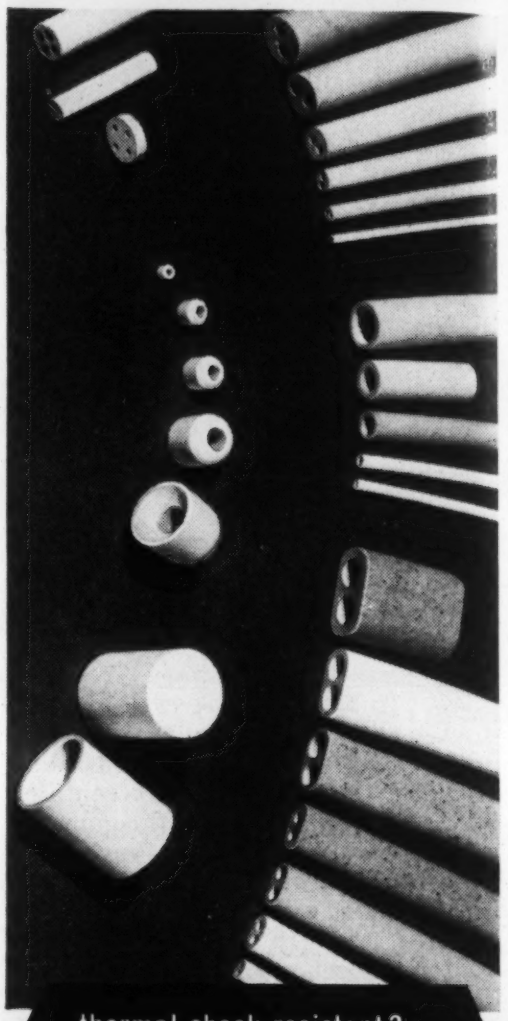

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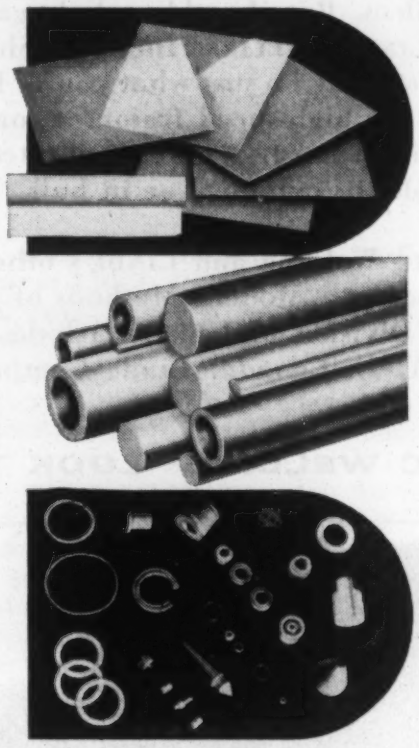

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This fall you will receive the MATERIALS SELECTOR issue for 1957. It will be mailed to you as the 13th issue of MATERIALS IN DESIGN ENGINEERING.

WHAT IT IS: All editorial pages of the MATERIALS SELECTOR will be in data sheet form. It will provide materials-specifying engineers, designers and other technical men with the most complete and best organized annual reference data available. It offers you two major editorial sections:

Data Section
- Comparisons of Materials
- Properties of Materials
  - Irons and Steels
  - Nonferrous Metals
  - Plastics and Rubber
  - Nonmetallics *(except Plastics and Rubber)*
  - Finishes and Coatings
- Forms and Shapes of Materials

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BOOKS & REPORTS

characteristics of alloyed iron and steel, engineering properties, application data, and an extensive bibliography. The book is well illustrated with tables, diagrams and photographs.

Reports

Corrosion of titanium THE CORROSION OF TITANIUM. *D. W. Stough, F. W. Fink and R. S. Peoples, Battelle Memorial Institute. Oct '56. 184 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. Price $4.75 (PB 121601)*

Corrosion rates of titanium alloys in various environments, a description of industrial and military corrosion experience with titanium, and the results of fundamental studies of the corrosion and passivating processes on titanium.

Porous materials EVALUATION OF POROUS MATERIALS FOR BOUNDARY-LAYER CONTROL. *D. E. Bebeau, Battelle Memorial Institute. Nov '56. 160 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $4 (PB 121851)*

Contains criteria for comparing various commercial permeable sheet materials for use in boundary layer control. Investigated were fibrous and perforated materials, sintered powdered metals and woven wire mesh. Types of sheet materials that provide the required range of permeabilities are discussed and their functional properties compared.

Airframe materials THE SELECTION OF MATERIALS FOR HIGH TEMPERATURE APPLICATIONS IN AIRFRAMES: SUPPLEMENT. *S. A. Gordon and L. R. Jackson, Battelle Memorial Institute. Feb '56. 30 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 75¢ (PR 121602)*

General information for design of airframes was derived from crippling tests at 800 F on channel and angle sections made of a titanium alloy. Results were compared with theoretical data gained from compressive stress-strain curves.

Plastics laminates ANALYSIS OF THE THERMAL PROPERTIES OF PLASTIC LAMINATES, CORES, AND SANDWICH PANELS. *R. F. Trapp, Wright Air Development Center. Jan '57.*

This alloy "shopping list" saves many a day for busy metallurgists!

AISI		AMS			SAE	
302	410	5333	5376	5631	30302	51442
303	414	5334	5378	5640	30303	51446
304	416	5350	5380	5643	30303F	60303A
308	420	5351	5382	5645	30304	60304
309	430	5352	5385	5665	30310	60310
309+W	430F	5354	5386	5700	30316	60316
310	431	5355	5388	5710	30321	60347
316	431A	5358	5389	5735	30347	60410
321	436	5360	5392	5765	51410	60420
327	440A	5361	5393	6270F	51414	60442
329	440B	5362	5394	6274F	51416F	60446
330	440C	5363	5526	6280C	51420	70310
331	440F	5366	5537	6350	51430	70310A
347	442	5369	5610E	6382	51431	70327
403	446	5370	5616	6428	51440A	70330
406		5372	5621	7834	51440B	70331
		5373	5628		51440C	70446
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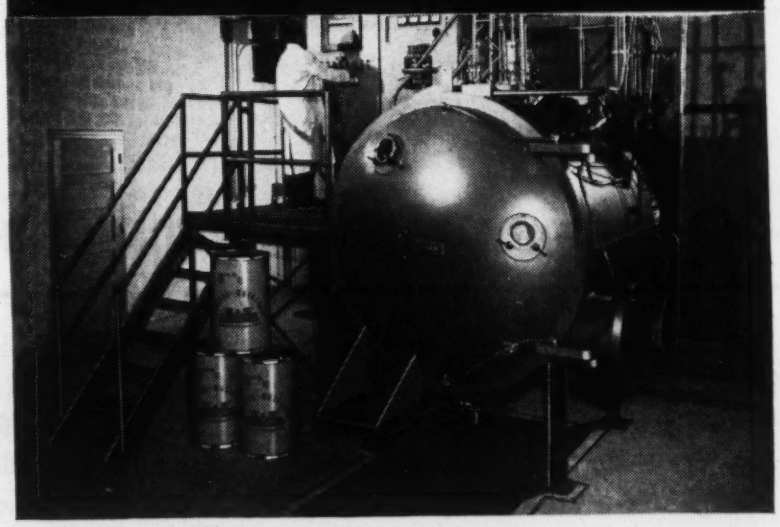

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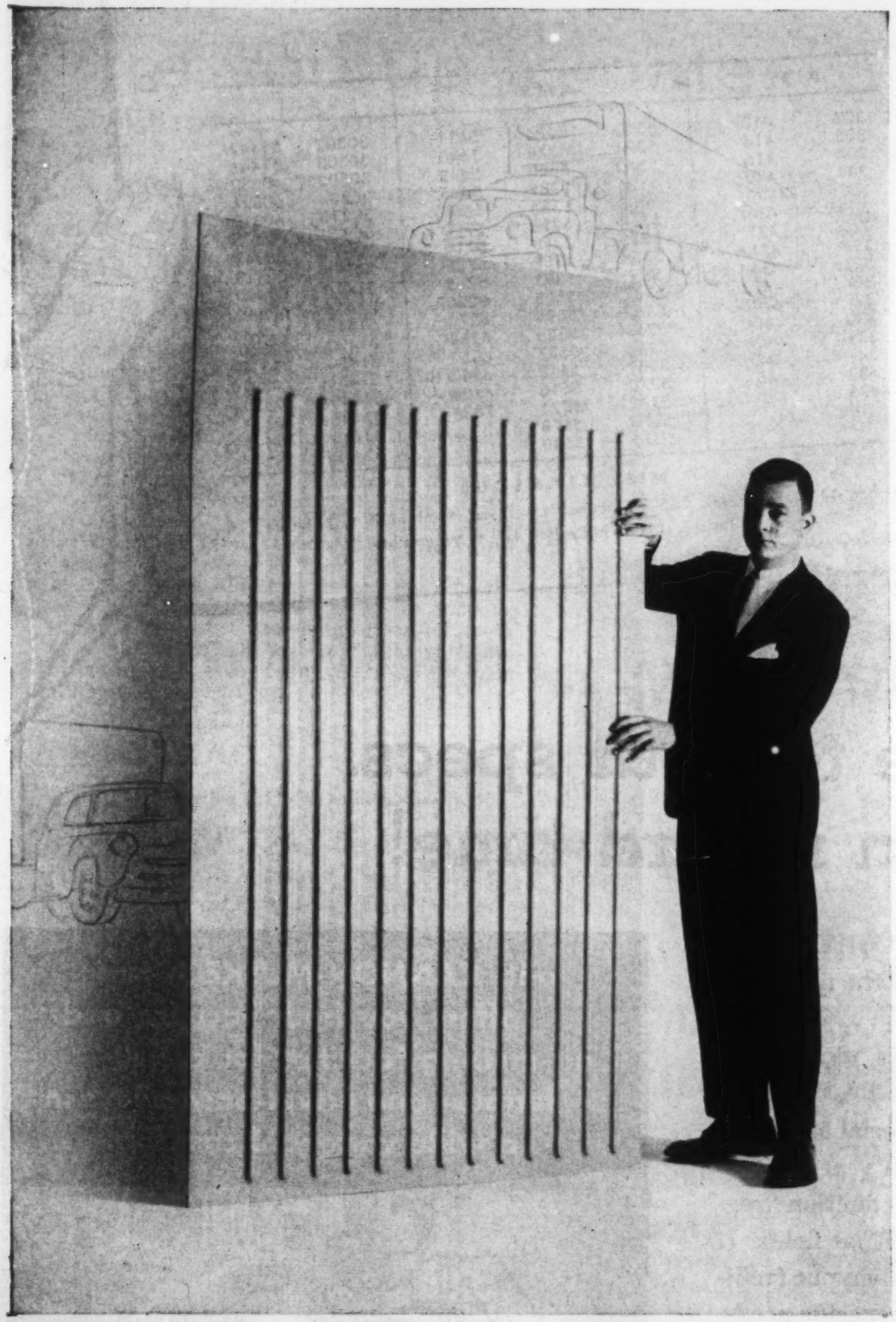

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BOOKS & REPORTS

18 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 50¢ (PB 121-882)

Gives data on the thermal properties of several plastics laminates, foam cores and sandwich panels. Information is designed to help engineers evaluate plastics material types for structural use at high temperatures. Mean curves for specific heat, thermal expansion and thermal conductivity.

Butyl rubber ENGINEERING STUDY TO DETERMINE THE FEASIBILITY OF USING BUTYL SYNTHETIC ELASTOMER IN MECHANICAL RUBBER ITEMS. FINAL TECHNICAL REPORT. *D. A. Meyer and J. G. Sommer, Dayton Rubber Co. Dec '55. 33 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1 (PB 121426)*

Evaluates the use of butyl rubber in such mechanical rubber goods as wheel cylinder and master cylinder boots, and air brake and windshield wiper house. Results show that butyl rubber is feasible for use in mechanical rubber goods. A number of plasticizers were found to lower the ozone resistance of the compounds to a level below that normally associated with butyl.

Cobalt-base alloys INVESTIGATION OF FORGED COBALT BASE ALLOYS FOR HIGH TEMPERATURE APPLICATIONS. *R. R. MacFarlane, R. K. Pitler and E. E. Reynolds, Allegheny Ludlum Steel Corp. Oct '56. 36 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1 (PB 121723)*

Improvements in the high temperature properties of a wrought cobalt-base alloy resulted from additions of aluminum, boron and titanium. Aluminum improved oxidation resistance and lowered rupture strength; boron increased rupture strength and ductility; and titanium improved room temperature hardness.

Cermets CERAMIC FIBER-BASE CERMETS. *L. J. Trostel, C. A. Hauck, J. C. Donley and T. S. Shevlin, Ohio Engineering Experiment Station. Mar '56. Photos, graphs, dwgs. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price 75¢ (PB 121354)*

Results of tests conducted on three ceramic fiber-base cermets containing 302B stainless steel and ceramic fibers and having a metal content of 91% by weight. Information on fabrication techniques.

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THE LAST WORD

by ***H. R. Clauser,*** *Editor*

Research, Chance, Pay-Off

The paths taken by free, unrestricted fundamental research are unpredictable and often seem wasteful and without purpose. But that they will invariably lead to worthwhile developments is almost a certainty.

Some of the new high density polyethylenes are an excellent demonstration of this fact. Dr. Karl Ziegler told the interesting story of their discovery at the opening of Hercules Powder's new plant for making this material. He said: "We did not start from the problem of how to make a new and better polyethylene . . . If we had started . . . in this way we probably never would have found the new method."

The beginning step that eventually led to the development of low pressure polyethylenes was taken by Dr. Ziegler in Germany, more than 25 years ago, when he started some fundamental research in the field of organo-metallic compounds from purely scientific points of view. The fascinating story of the creative research that followed is too long to tell here. But the research followed a meandering path of failure and success, until finally in 1953 an experiment originally planned for quite another reason provided the key to the discovery. The experiment unexpectedly revealed how to activate aluminum trialkyd to serve as a catalyst for the polymerization of ethylene at normal pressure.

Thus the final discovery was made by chance. But it was a chance discovery only made possible by the accumulation over many years of fundamental knowledge in the field of organo-metallic chemistry.

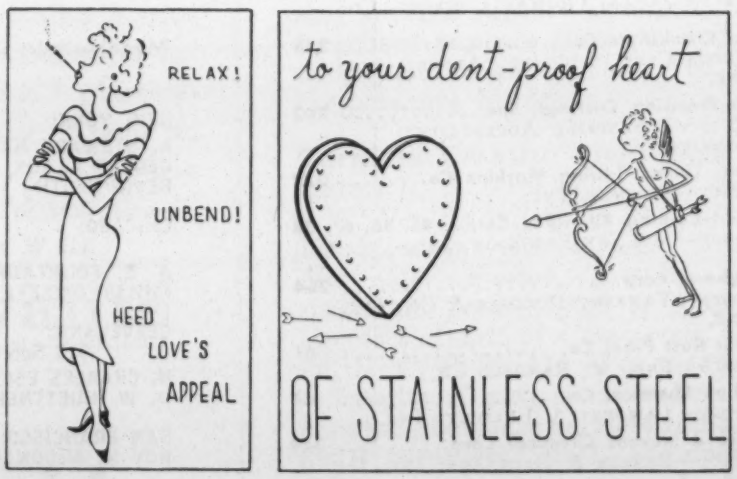
Squirt Gun Suits

If you dislike shopping for clothing and can never seem to find a suit that fits or has the right color, you should find hope for the future in the predictions of Sir Harry Jephcott, chairman of Great Britain's National Council of Scientific Industrial Research. He predicts that materials technology and electronics will team up to produce not only fabrics to exact order, but also suits that are guaranteed to fit perfectly.

According to Sir Harry, fabrics will be manufactured by an amazing electronic machine into which will be fed the raw materials, such as fibers, chips, pigments and solvents. The machine will be directed by a code card punched to indicate the weight, strength, color and weave desired.

The next advance will be even more spectacular. A fabric in liquid form will be sprayed on a dressmaker's dummy shaped to your dimensions. When the liquid solidifies, the result will be a sort of space suit that fits you like a glove.

Stainless Heart Throbs

During the past few months I have been receiving greeting cards from a secret pal. One card is reproduced here. Two of them have been birthday cards, although I'm perfectly satisfied with just one birthday a year.

One thing is certain: the cards are coming from a real promoter. If he thinks this is the way to attract notice to his client's material, he's right—as you can plainly see.